Popular Astronomy

Vol. XL, No. 2 FEBRUARY, 1932 Whole No. 392

Edward Skinner King (1861-1931)

By CECILIA H. PAYNE

The life work of forty years, dedicated to the advancement of astronomy, was ended when Professor Edward Skinner King died in Cambridge on September 10, 1931. When, as a young man, he took up the task, he found the science near a turning point. With striking foresight he envisaged an exploration of the new territory; and he lived to see his work essentially completed in the form in which it had been planned. The problems that he confronted were of the most fundamental kind—problems that tax the endurance of the worker because of their laborious nature, and their slowness in coming to fruition. But fundamental problems have also their reward, and Professor King was one of those who can be conscious of having laid the permanent foundations of their science.

Mr. King was born in Liverpool, New York, on May 31, 1861. His paternal ancestors brought him a scholarly tradition: four generations had been highly educated, and when, in 1927, he received an honorary degree from Hamilton College, he was repeating the achievement of one of his grandfathers. In 1887 he was graduated as Bachelor of Arts from Hamilton College, and received the degree of Master of Arts there in 1890. During his college days he was primarily interested in mathematics, distinguished himself in that subject, and won the Mathematical prize. The professor of mathematics and astronomy at Hamilton College at that time was Dr. C. H. F. Peters, and to his interest and incitation Mr. King's first entrance into astronomy is to be ascribed.

Professor Peters, having taken Mr. King for his own assistant and realized his quality, sent him in 1887 to Professor Pickering, who had then been ten years Director of the Harvard Observatory, and who was still on the threshold of the great advances that took place in the Observatory under his guidance. Pickering found in the shy and diffident young man a person who could undertake responsibility, for within two years Mr. King was left in charge of the Harvard station near the summit of Wilson's Peak, California, and close to the present buildings of the Mount Wilson Observatory.

In 1890, after his return from the Mount Wilson station, Mr. King married Miss Colson, of Batchellerville, New York, and with her he shared the remainder of his life. Two of their children survive him; the third, Everett Tryon, died in 1918, cutting short what gave promise of being a distinguished career. The first few years of his married life

were clouded by failing sight, but in 1893 his eyes were so far strengthened that he was able to return to his temporarily suspended duties at Harvard. Thenceforward until 1931 Mr. King superintended the extensive and growing photographic work of the Observatory.

In 1887, when Mr. King first joined the staff of the Harvard Observatory, little or no systematic photographic work had been done either there or at any other Observatory. Under his supervision, and as a part of the ambitious plans that the Observatory undertook at that time, two extensive programs were undertaken: the standard testing of all photographic plates used, and the photographic photometry of astronomical objects on a uniform scale.

At present it is difficult to visualize the magnitude of the task undertaken in the setting up photographically of a uniform photometric scale; both the technique and the logical basis of the method had to be developed *ab initio*. That clearness of perception guided the planning, and that the utmost accuracy was observed in carrying it out, are shown by the permament status still occupied by the first photographic magnitudes of stars determined by King. For the bright stars (to which alone his work extended) his determinations of photographic, photovisual, and red magnitudes will long be standard, and this in a branch of precise astronomy that is notoriously difficult of conquest.

An example of the accuracy of the work is worth quoting. In various papers on the photographic magnitudes of bright stars, published in Parts 4, 5, and 6 of Volume 59 of the *Harvard Annals*, the standard of reference had been the brightness of Polaris. When, later, the Pole Star was found by Hertzsprung to be variable, Mr. King examined the residuals for the plates standardized by means of this star, in order to find whether the variability of the standard could be detected. "There is no doubt," he wrote, ". . . that there is a real variation in the light of Polaris. [The figures] all show practically the same curve, of substantially the same form and amplitude as Hertzsprung's, and confirm his discovery . . . I think it should be noted that no special plates or measures have been used to obtain these results. All the material has been derived from matter already in type." When it is recalled that the measured amplitude is a little over a tenth of a magnitude it is clear to any one who has attempted photographic photometry that the precision of the measures must have been remarkable.

The program of standard tests of photographic plates, a far-sighted plan in 1887, and implying a very real grasp of the nature of the photometric problem at its very outset, was carried on continuously for forty years. In addition to the valuable specific information about the plates used, this work made Professor King the master of a wealth of knowledge about photographic method. Again and again an enthusiastic novice would take to him a plan for some minor technical device in photographic photometry; only to be told, with a humorous twinkle: "I tried that ten years ago; it won't work," (a discovery more than once

privately confirmed by the sceptical). Some of the fruits of the photographic experience of forty years are stored in Mr. King's "Manual of Celestial Photography"; some persist, unacknowledged it may be, in the practice and routine instructions of the Harvard photographic department; as many more, perhaps, have been lost to us.

The three great programs: supervision of the Harvard Observatory photographic work; standard photometry; and standard plate tests, faithfully pursued for forty years, would in themselves be a satisfactory life work. In regard to the first of these, Dr. Shapley, Director of the Harvard Observatory, wrote in the foreword to Professor King's "Manual":

"Hundreds of thousands of celestial photographs have been made with the Harvard telescopes within the past forty years, adding appreciably to our stock of knowledge of the sidereal universe. A large proportion of these plates has been made under the supervision of Professor King, the author of this volume, who has thus been directly responsible, in both general methods and particular details, for the production of more celestial photographs than have been made by any other living person." Photographic astronomy will for decades be indebted to Professor King for much of its immediate subject matter.

In addition to the routine program, Professor King's work abounds in ingenious methods, sometimes with important results. He was the first to photograph the spectrum of the Aurora Borealis, and he devised a method for the photographic observation of the occultation of stars and planets that is elegant in its simplicity. It is well known, also, that he was an independent discoverer of the Hartmann-Cornu formula, although he did not publish his result until long after Hartmann had done so. Better known, perhaps, are his determinations of the apparent magnitudes of the sun, moon, and earth (the latter by means of the intensity of the light reflected from the unilluminated portion of the new moon).

The lifetime of punctilious scientific work did not go unrecognized. Mr. King was successively Observer (1887-1913), Assistant Professor (1913-1926), and Phillips Professor (1926-1931) at the Harvard Observatory. His tenure of the Phillips Professorship ended on September 1, 1931, and this moment was the occasion of a sincere and spontaneous expression of regard from every member of the staff of the Observatory. He practically lived out his life in office, surviving his resignation only ten days. He was a Fellow of the American Academy of Arts and Sciences, a member of the American Astronomical Society and of the Société Astronomique de France, an Honorary Member of the Maria Mitchell Association, and a member of Phi Beta Kappa. In 1926 he received the honorary degree of Sc.D. from Hamilton College.

Mr. King possessed a lifelong friend in Professor Solon I. Bailey, who joined the staff of the Harvard Observatory in the same year, and whose death occurred in June, 1931. During the last days of his life,

weakened by illness and not unaware of the inevitable outcome, Mr. King devoted his energies to writing a beautiful and sincere tribute to the memory of his friend.* It is common to such biographies that they describe much of the character of the writer as well as that of the subject, and the reader will find in it not only Mr. King's charming style of writing, but also a reflection of the aspirations that shaped his own life and of the tastes that colored it.

To his colleagues Professor King remains a very individual figure: profoundly faithful to his work, and intensely loyal to the Observatory. During his supervision of the photographic programs, he was infallibly present at the Observatory on every clear evening, except during his brief vacations (and sometimes even then). Those who sought his advice in scientific matters found in him a careful and valuable critic, always ready with his fund of accumulated knowledge.

Another side of Mr. King was probably known to only a few. He delighted in books, and treasured those which had the flavor of antiquity. The discovery of a common passion for old classical texts would bring him often to one's office, diffidently producing one of his treasures to be admired. At such times he would lay aside some of his shy manner, and appear as a delightful raconteur, ranging widely over the departments of human interest.

It is, perhaps, fitting to close with a tribute from the friend to whose memory Professor King devoted some of his last energies. Professor Bailey, writing to Mr. King only a few days before his own death, spoke in retrospect of his friend's life:

"To have done work which is widely recognized, to have gained the sincere esteem of many and the real love of even a few, surely these are sufficient reasons to look on life as well worth the living."

HARVARD COLLEGE OBSERVATORY, JANUARY 10, 1932.

*POPULAR ASTRONOMY, **39**, 456, 1931.

Planet *U*, and the Orbits of Saturn and Jupiter

By WILLIAM H. PICKERING

The first person to detect that there was something very unusual about the orbit of Saturn was that important, but comparatively little known, planetary computer, the late Dr. George W. Hill. His tables of Saturn are still the standard ones after more than thirty years. According to Crommelin, Hill remarks "The residuals of the R.A. of Saturn frequently show a systematic character * * * All the efforts I have made to detect periodicity in them have led to no result * * * Either some error has been committed in the theory, *or some force acts on Saturn of which we know nothing,* or the observations are affected with systematic errors." The italics are mine, and Hill's two other suggestions are improbable for such large deviations.

In POPULAR ASTRONOMY for 1929 I published three papers on the subject, in which I showed that there were two possible solutions of the problem. The one which I selected was that Saturn was attended by a very remote satellite whose period apparently was 26.18 years, but was really 13.86. This extraordinary difference was due to the very long period of the satellite, nearly half that of Saturn, as shown in my first paper. Its mass was computed to be 0.42 that of Titan, or 0.78 times that of our Moon, and it was revolving about Saturn with a direct motion. By the introduction of such a hypothetical body the average deviation in longitude of Hill's orbit between 1860 and 1928 was reduced from $\pm 0''.54$ to $\pm 0''.27$. For comparison we may state that the average deviation of the longitude of Uranus between 1854 and 1897, while it was unperturbed by the unknown planet *P*, was $\pm 0''.34$. I also showed in my first paper that, although the satellite had apparently made only 2.5 revolutions about Saturn in that time, yet, owing to the great difference between its apparent and real periods, it had really made 5.0. Figure 1 is taken from that paper, 1929, **37**, 212. The upper row of observations, extending as far as the year 1900 is a plot of Hill's deviations in heliocentric longitude. After that date published deviations of Greenwich and Washington were used, as there described. The second row shows these deviations after they had been adjusted by the sinusoidal method so as to better fit the case of a satellite. The third row shows the improvement effected by the introduction of such a hypothetical satellite. It will be noticed that this improvement exists only for the last 70 years.

The difficulty in predicting the present position of the satellite was two-fold. In 1911 Washington made material changes in their transit instrument, and in 1915 Greenwich made other changes in theirs. This

produced in each case a marked hiatus, amounting to between 1″ and 2″ of longitude in their results, but still worse, their measures of the latitude of the planet also differed greatly, giving different nodes and inclinations, so that we did not actually know at that time whether Saturn lay to the north or to the south of its computed place. Indeed the latitude curves were so unlike that it was impossible to combine them, and so two diverse solutions of the problem were computed. At the Lick Observatory photographs based on the Washington measures gave no indication of the satellite. At Mount Wilson a considerable number of plates were taken, but unfortunately, owing to some misunderstanding, not in the predicted place according to the measures made at Greenwich.

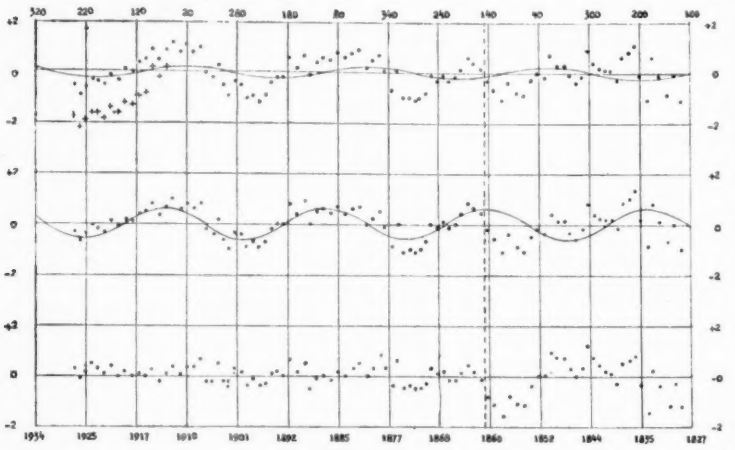


FIGURE 1.

THE PERTURBATIONS OF SATURN.

We have just spoken of there being also two different methods of solving our problem, one being to consider the unknown object as the satellite above mentioned, and the other to treat it as a small companion planet to Jupiter, having an analogous relation to that planet as Pluto has to Neptune, and as Eros has to the Earth. Both of these solutions appeared to imply the very serious objection that any body sufficiently massive to produce the effect observed on Saturn should be so bright as to have been discovered telescopically long ago. This statement is based on its mass relatively to Titan and to Pluto. As a consequence, since it has not already been discovered, it would appear either that its albedo must be exceedingly small or else that the density of the little body must be very high, both of which suppositions seemed to be unlikely. No one has as yet succeeded in measuring the angular diameter of Pluto, although several have doubtless tried to do so, and no one as yet has even confirmed the statement of M. Baldet, made in 1929, who, using the

32-inch refractor at Meudon, declared that the diameter cannot exceed 4000 miles. It would appear that M. Baldet's observation requires confirmation.

The chief reason why I disregarded the second solution two years ago, and selected the first one in its place, was that the second hypothesis involved an object averaging some ten times farther from Saturn at conjunction than the first, and therefore apparently much more massive, larger, and brighter. It would also be appreciably nearer and more brilliantly illumined by the Sun, and therefore more likely, if genuine, to have been previously discovered. We shall later show that this objection does not necessarily hold. We shall therefore now discard the so-called theoretical satellite *U*, and replace it by a small theoretical planet bearing the same designation, and as we shall presently see, in some respects resembling it.

Very fortunately since my last paper on the orbit of Saturn was published, a very important one on the orbits of Jupiter and Saturn by Messrs. Hammond and Morgan has appeared in the *Astronomical Journal*, 1930, **40**, 85. It contains a revision of the orbits of these planets as observed at Washington from 1895 to 1929 inclusive. It gives their observed deviations in right ascensions and declinations as well as in longitudes and latitudes, but does not state whether the latter are heliocentric or geocentric. The headings of the columns λ and β might imply the former. A recent letter, however, states that they are the latter. Greenwich has also published a revision of its results in geocentric coördinates, from 1900 to 1928 inclusive, in the *Monthly Notices*, 1929, **89**, 260. For our purposes it would have been better if both observatories had given heliocentric coördinates. As far as the longitude of the unknown planet is concerned, whether geocentric or heliocentric makes little difference, but for the latitudes we should subtract 5 per cent for Saturn from the published results, and for Jupiter 10 per cent. In plotting the curves, however, we shall use the published figures. Since the Washington and Greenwich observations of these planets now agree very satisfactorily, we shall use them in this paper as far as is possible.

In plotting our results in Figure 2 the heliocentric longitudes corresponding to the published dates have been used as abscissas, and the published deviations as ordinates, the approximate dates being placed at the bottom of the figure. The upper curve shows the deviations in longitude, and the lower those in latitude. Positive ordinates indicate that the known planet is ahead, or to the north of its computed position. The Washington observations, as formerly, are indicated by circles and those of Greenwich by inclined crosses. In most cases two series of observations are available, and the points midway between them have been joined by a broken line. Single observations are not so connected. It is of course understood that each so-called observation is the mean of a long series made on different nights. In only two cases have observations been rejected for exceptionally large deviations. The only curves

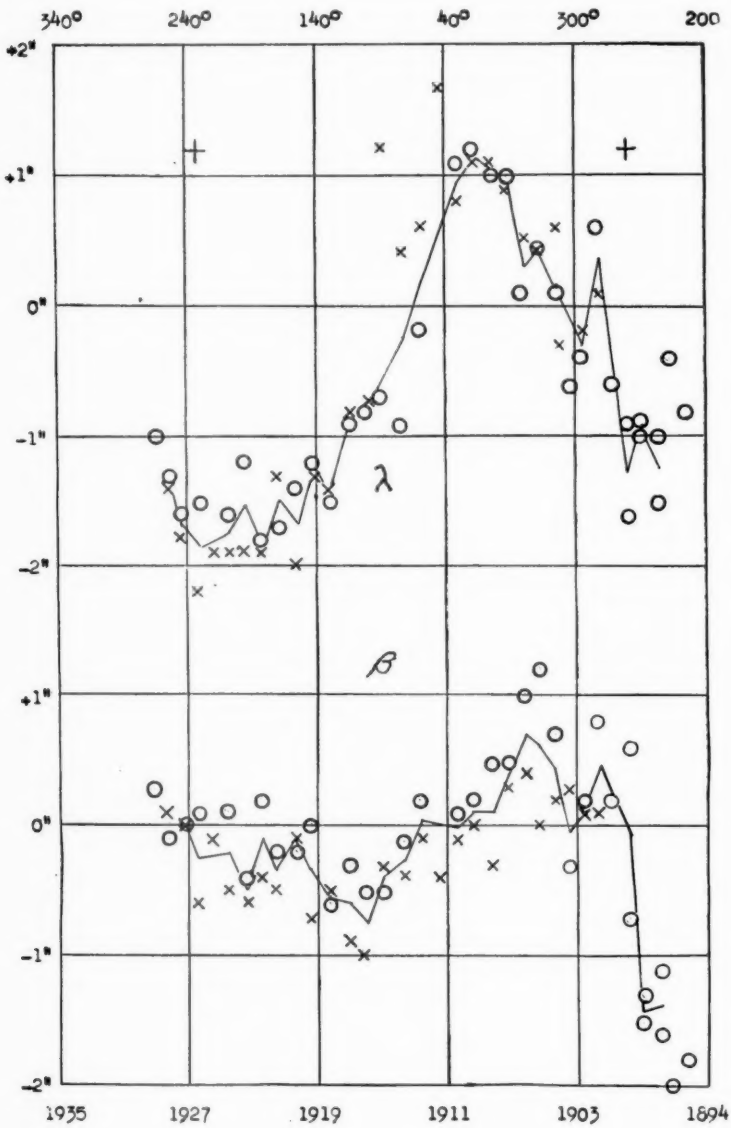


FIGURE 2.

RECENT PERTURBATIONS OF SATURN.

that we have that will show what changes have been produced by the recent revision of the deviations, are the upper ones of Figures 1 and 2 between the dates 1895.4 and 1927.4. By them it will be seen that the dates of maxima and minima are in general in practical agreement, although the amounts of the variations vary somewhat among themselves. We feel that we may therefore safely use the longitude of the minimum of 1872.6 taken from the table number III published with the curve of Figure 1 in 1929. The corresponding heliocentric longitude for the former date, and not corrected for precession, is 289°.8. The two minima shown in Figure 2, which we shall call the second and third, are for 1899.4, heliocentric longitude 261°.1, and for 1926.4, longitude 233°.1, and are indicated by vertical crosses above the curve. It will be noticed that we are here using the minima of the curves for our computations instead of the maxima as heretofore. The reason for this is that in the present case the unknown planet is revolving in an orbit within that of the known one, and therefore overtakes it instead of being overtaken. In the former cases the unknown planet first pulled the known one forwards, and then after conjunction backwards. In the present case just the reverse occurs, the unknown first pulling the known one backwards, and then later forwards.

It is very clear by the upper curve of Figure 1, as above noted, that prior to 1861 for some unknown reason the deviations are so irregularly disposed that nothing can be done with them. This is strange, because it does not seem likely that the observations of Saturn suddenly became good, or rather ceased to be bad, in the year 1861, for the observations of Uranus were just as good, with only small deviations, in 1854 as they were in 1897, throughout the long period during which that planet was unperturbed by any unknown large outside planet, as we have seen in my former papers. The long interval between the two minima in 1872.6 and 1926.4 of 53.8 years, when divided by 2, gives us as an overtake period of Saturn and *U* 26.9 years. The corresponding true period in a circular orbit would be 14.0. We shall presently show that it is really 13.93. The apparent period of satellite *U* we recall, by my third paper, was 26.18 years, and the corresponding true period 13.86. As a planet it now revolves, however, at a much higher speed than on the former supposition, since its orbit now centers on the Sun, and its corresponding mean distance is 5.79, as compared with that of Jupiter and Saturn of 5.20 and 9.54. Its mean distance from Jupiter at conjunction is 0.59, and from Saturn 3.75. The two outer satellites of Jupiter are at a distance of 0.16 from their primary on the same scale. Its orbit intersects that of Jupiter, and the little planet therefore sometimes lies nearer to the Sun. When the line of nodes of its orbit passes through the intersection of its orbit with that of Jupiter, *U* would pass through the satellite system, but long before that event could occur the orbit of *U* would generally be greatly perturbed and changed by the great planet.

Since at conjunction *U* always lies nearer to Jupiter than to Saturn, and because it stays much longer with it, since their periods are so nearly equal, we might naturally suppose that it would perturb that planet much more than it does Saturn. Doubtless it does do so, but because they do stay together so long, and because the perturbation takes place so gradually, these are the very reasons why the effect does not show as conspicuously as we might expect. Indeed its effect is partly included in what is therefore really an erroneous theory of Jupiter. In case it and *U* both moved in circular orbits their overtake period would

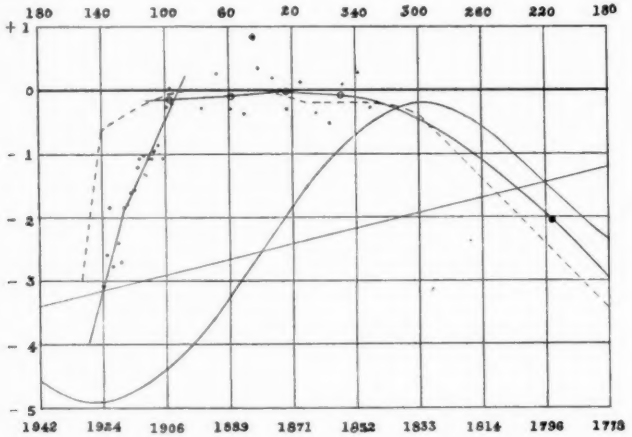


FIGURE 3.
ACCEPTED ORBIT OF NEPTUNE PERTURBED BY PLANET *O*.

be 80 years, but since the orbit of *U* is quite eccentric, as we shall presently show, this period may vary through a small range.

Figure 3 is taken from Figure 4 of "The Next Planet beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 150, and shows the deviations in longitude of Neptune as perturbed by Pluto before I applied the sinusoid curve to correct them, and give them the proper shape of a perturbation curve. In my recent paper on Planet *P*, POPULAR ASTRONOMY, 1931, **39**, 386, Figure 2, I show the standard form of perturbation curve derived from the present Figure 3 after a suitable sinusoid has been applied. In Figure 4 of the present paper are given two curves for the planet Jupiter, analogous to those shown in Figure 2 for Saturn. The peak in the upper curve occurring in 1905 and the depression in 1910 are each derived from a single year's observations. Disregarding them, a fair degree of resemblance is found between Figures 3 and 4, and we see that just as a sharp change in the curve for Neptune may be recognized in 1904 at longitude 95°, where the sudden drop in the perturbations begins to occur in Figure 3, even before applying the

sinusoid, so a similar drop occurs in the perturbations of Jupiter in 1922.3, at longitude 195°.3 in Figure 4. And just as in the case of Pluto, the maximum perturbation after applying the sinusoid occurred one year and a half earlier in 1902.4, POPULAR ASTRONOMY, 1930, **38**, 288, so in the case of *U* it occurred a year earlier in 1921.2 at longitude 164°.7 as is indicated by the vertical cross. Since in this case *U* is more

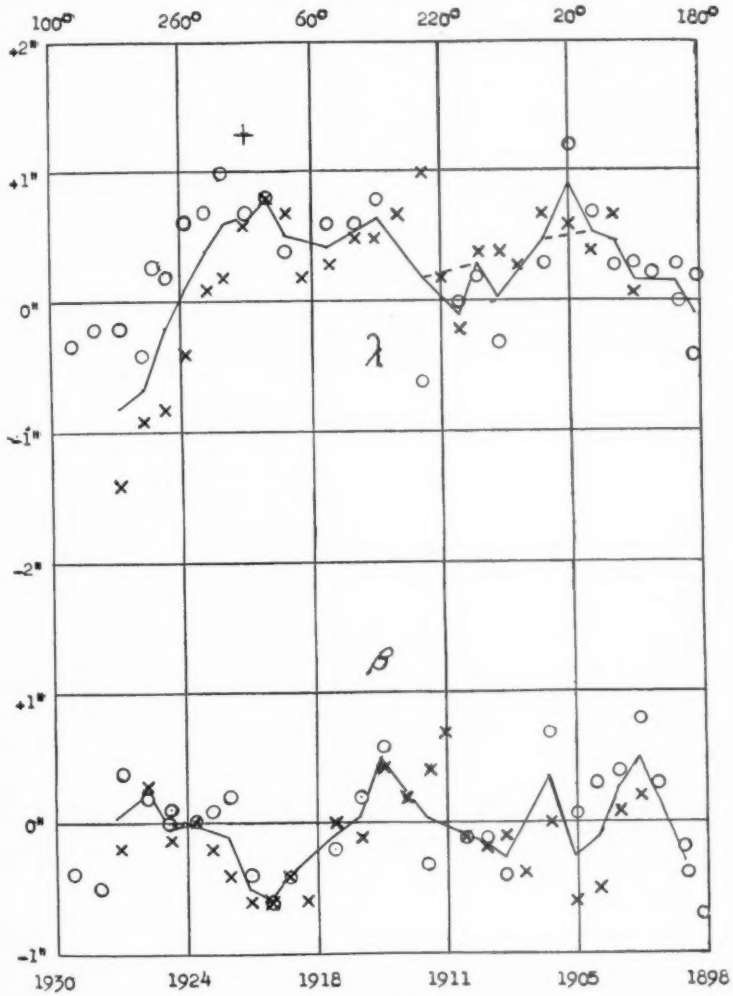


FIGURE 4.
RECENT PERTURBATIONS OF JUPITER.

remote than Jupiter maximum ordinates are employed.

We thus have four dates when planet *U* exercised a maximum perturbation on the planets Jupiter and Saturn, and we also have the heliocentric longitudes of the two great planets upon these four dates. But we must now recall that the maximum perturbation of the known planet does not occur at the time of its conjunction with the unknown, but *always* several years *later*. This is a distinct help in finding the longitude of the unknown. In case the orbit of the known planet lies inside the orbit of the unknown, as in the case of Jupiter and *U*, since Jupiter is travelling faster, usually, than *U*, we must subtract a number of degrees from the longitude of the known planet on the date of its maximum perturbation to find the longitude of the unknown. On the other hand, if the known planet is farther away than the unknown, as in the case of Saturn and *U*, the latter will be travelling faster, so that we must add a certain number of degrees to the longitude of the known planet to give us the longitude of *U*. In the case of Uranus and Neptune the proper correction to be made to the longitude of the known planet in order to give us the longitude of the unknown one (Neptune) we found to be —8°.2. In other words this was the angular distance between them as seen from the Sun at the time of the maximum perturbation of Uranus. This gives an angle between the Sun and Neptune as seen from Uranus of 157°.9, which is taken as a constant in the case of any unknown outer planet, the angle at the Sun being determined when the distance of the unknown planet is known. For an unknown inner planet we use the supplement 22°.1. Since these two constants lead to satisfactory correcting angles by means of which to deduce the longitude of the unknown planet, from those which are known, whether the latter are outside or inside the orbit of *U*, and since Pluto was found by means of them, it is believed that they may be considered to be fairly accurate.

These numbers were originally obtained by observation, not theory, which is my reason for describing this method as empirical. In case the derived number, —8°.2 above, were a large one, such as 30° or 40°, and there were no way of determining its approximate value, then the method would be of no use whatever. It is because the number is necessarily small, since the maximum perturbation always follows the conjunction by several degrees, but cannot be far from it, that the method has derived its value. For an unknown outer planet the correction must be negative, but even before conjunction the radial component of the perturbation acts, because when the known planet is pulled away from the Sun it necessarily revolves more slowly. This component reaches its maximum value at conjunction, at the time that the tangential component is reduced to zero. Before conjunction the two components are acting in opposition. After conjunction both the components are pulling the planet backwards, and soon overcome its increased speed. The maximum perturbation therefore cannot lie far beyond the line of

conjunction, and is in this case a negative quantity. Probably 20° for a remote planet would be its maximum value. The possible range in any particular case would be far less than this, possibly 4° either way, depending somewhat on the individual case, and with modern photographic methods that would not be too large to be practical. In the case of an unknown interior planet the same number holds good, since the two planets reach their maximum perturbations at the same time.

In what precedes I have endeavored to make it clear that this empirical method of solution differs fundamentally from that of Adams and Leverrier, in that it depends solely on the date and longitude of the maximum deviation, and not at all on its amount. Excepting to pick out the maximum, we care nothing whatever for the amount of any of the deviations. This is why the empirical method enabled me in the case of Pluto, for instance, to make use of the orbit of Neptune, and its large perturbation of nearly 4″, although only half of its orbit is as yet known with any real accuracy. The method of Adams and Leverrier, depending as it does on the amount of the perturbations, requires a nearly complete orbit, and it is for this reason that the other computer had *per force* to confine his investigations to the orbit of Uranus, which showed such slight and doubtful deviations that it is no wonder that he was unable to locate Pluto with any accuracy, or as he himself put it, only "with the promiscuity of a shot gun" instead of "the precision of a rifle." I am far from wishing to belittle his effort, and feel, considering the inadequacy of his data, that he came astonishingly near the truth.

Returning now to the present investigation, it is felt that with the accuracy of modern observations, such striking systematic irregularities in the motions of the two major planets of our system, amounting to something like 3″, are most regrettable, and that if an intermediate planet exists, it is most important that it should be found. A solution by the method devised by Adams and Leverrier should be most inviting to a good mathematician, on account of the unusually large amount of accurate material available. On the other hand a solution of the problem of four bodies, and an investigation which even if only carried back for the last thirty-five years, is not to be lightly undertaken by any man past middle life. On account of the large perturbations found, amounting to from two to three times those of Uranus due to Pluto, and the far greater accuracy of the observations themselves, such an investigation would be much more promising of useful results than was the search by that method for Pluto itself. It is hoped, however, that photographs based on the present investigation may render such a prolonged computation unnecessary.

Since the perturbations of Saturn prior to 1861 do not conform to the present orbit of *U*, it might have been thought that it was hardly worth while to see what could be done with Jupiter at a still earlier period. Nevertheless since those particular observations may have been defective, the deviations themselves certainly being far from systematic

(see Fig. 1), and since Hill's tables of Jupiter go back to the year 1750, it seemed as if during the long interval that had elapsed since that date some perturbations of the great planet might have occurred which would give us additional information. Washington kindly sent me the tables, and I have plotted their contents in Figure 5. This is arranged like the previous Figures, the heliocentric longitudes which serve as abscissas being given at the top of the table, and the corresponding dates below each curve. The length of each rectangle is 360°. The observations of the upper curve are so irregular that it appeared desirable to smooth it, which was done in the usual manner by plotting the means of each three successive observations, each observation therefore being included three

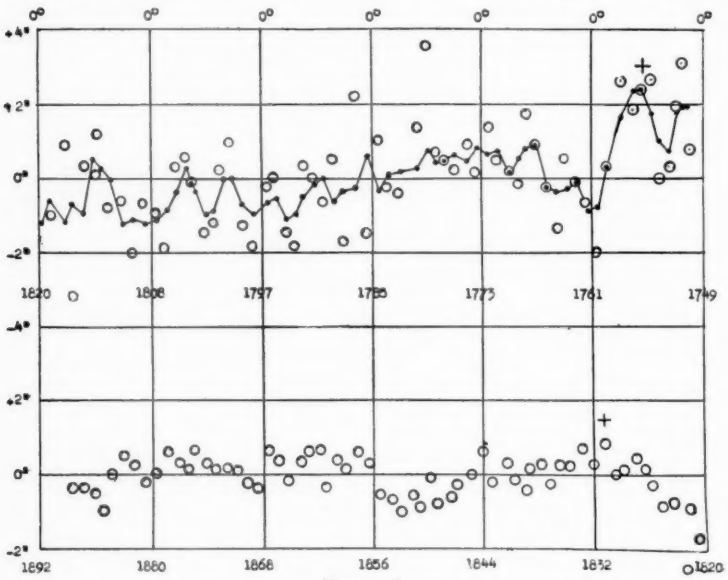


FIGURE 5.

EARLY PERTURBATIONS OF JUPITER.

times in the final result. The observation of 1779 alone was rejected as erroneous. The overtake period of Jupiter and *U*, 80 years for circular orbits, is rather unexpectedly long. Since the last perturbation of the former occurred in 1921, we looked for two others somewhere near 1841 and 1761. The first pronounced maximum that we see in Figure 5 is dated 1756.1 in Hill's table. We notice also that the curve is of the same general shape and steepness, allowing for the difference of scale, as that in the upper curve of Figure 4, in which curve also no allowance has been made for the effect due to an unknown planet. The greater extent of the earlier perturbation would imply that the two planets were

then nearer to one another, and that an advance of the perihelion had therefore occurred between the two dates due to the intermediate conjunction.

While this maximum stands out very markedly above all the observations which follow it, the only other maximum that we can find at all on the curve, that at 1831.7, is rendered noticeable only by the depressions which precede and follow it. However, had it projected prominently in the original observations, Hill, naturally believing that it was due only to accidental errors, would certainly have done everything legitimately possible to reduce all deviations to a minimum. In conformation of this view, we note the uniform gradual downward slope of the upper curve, which should really of course be level after passing the perturbation, in case no other unknown body interfered. This depression reaches its maximum value, between 1″ and 2″, at the beginning of the lower curve, and if the deviations about 1820 were raised to a level with those made 50 years earlier, then those made about 1831 would stand well above those following them, if the more recent ones are correct. The shape of this maximum and its small amount therefore do not necessarily cause its rejection, particularly as we shall presently see that there is another excellent reason, possibly more cogent still, why it should not stand very high.

TABLE I.

THE COMPUTED ORBIT.

Period 13.93 years. Eccentricity 0.26. Date of Perihelion 1929.7. Longitude of Perihelion 1°.8.

Planet	Saturn	Saturn	Saturn	Jupiter	Jupiter	Jupiter
Date of Maximum	1872.6	1899.4	1926.4	1756.1	1831.7	1921.2
Mean Anomaly	—36°.2	—62°.0	—85°.3	—165°.4	—12°.9	+139°.5
True Anomaly	—59.3	—91.6	—114.5	—171.1	—22.5	+154.8
Longitude of Perihelion	1.8	1.8	1.8	1.8	1.8	1.8
Computed Longitude *U*	302.5	270.2	247.3	190.7	339.3	156.6
Longitude known Planet	290.6	261.6	233.2	196.0	321.8	164.7
Correction for *U*	+11.4	+10.3	+ 9.0	— 4.0	+ 1.5	— 4.2
Observed Longitude *U*	302.0	271.9	242.2	192.0	323.3	160.5
O—C	— 0°.5	+ 1°.7	— 5°.1	+ 1°.3	—16°.0	+ 3°.9

In Table I is given an abstract of the computations. The first two lines give the four constants finally selected for computing the orbit, the next the name of the known planet whose maximum perturbation was detected in each of the six cases, the next the date of this maximum selected from the curves, and recorded in the Washington and Greenwich tables. The next two give the mean and true anomalies, and the line following, the above mentioned longitude of the perihelion. The inclination is small, and the longitude of the node uncertain, which will explain why we do not use the argument. The sum of the true anomaly and the longitude of the perihelion give us the computed longitude of *U*. These six computed longitudes depend merely on the four constants given in the first lines of the table and the six chosen dates given in the

fourth. They show us, without using any longitudes whatever except that of the perihelion, given these quantities, where under the law of gravitation the unknown planet ought to be.

The next row gives us the longitudes of the known planets, reduced to the epoch of 1932.0 at the dates above mentioned, on which we have decided from the curves that the planets showed their maximum perturbations. It is from these numbers indeed that the dates at the heads of the columns were obtained, using the Greenwich and Washington tables above mentioned. Given the distance of *U* and of the known planet in each case at the time of the maximum perturbation, the correction to the longitude of the known planet in order to give that of *U*, computed as above described, is given in the next row. (See also POPULAR ASTRONOMY, 1928, **36**, 159.) The following row gives us what we have called the observed longitude of *U*, because it is based on the observations of the known planets made at Greenwich and Washington. These longitudes have nothing whatever to do with the law of gravitation, but are strictly observational. The same constant angle 157°.9, derived from the perturbation of Uranus by Neptune, which served to give us the accurate location of Pluto, and the as yet undetected position of *P*, now applied to the six positions of Saturn and Jupiter, give us an elliptic orbit for *U*, which we shall now proceed to show is as accurate as could be expected from the data furnished. We see no reason at present to modify this constant.

The differences between the longitudes as given by these two determinations of *U* in each column are given in the last row. While to those who are used to dealing with cometary orbits, and the orbits of the asteroids, where the object computed is actually itself observed, these differences may perhaps seem pretty large, yet if they will turn back to Figures 2 and 4, they will notice that the length of each square in the case of Saturn is 100°, and in the case of Jupiter 200°, so that a deviation of even —5°.1 in the case of Saturn is no more than what we might fairly expect. The fifth deviation, however, is quite a different matter, although it might indicate an error of only two years at the end of eighty in selecting the date of maximum. Such an error, however, is not permissible, and we shall discuss it presently. We must now recall that all the observations on which the orbit is based are taken in groups of a year apart, and that they are not sufficiently accurate to make it worth while to attempt to use intermediate values. Thus turning back to the upper curve in Figure 2, and to the circle and cross in 1926.4 we see that we cannot tell with certainty whether the minimum occurred then, or whether it may not have occurred at the previous Greenwich observation in 1925.4, which is a little lower. Unfortunately no observation was secured at Washington in that year, but if we assume that the latter date was correct, our error instead of being —5°.1 would become +4°.3. It thus appears that the maximum perturbation should probably really have had an intermediate date.

Figure 6 is constructed by means of Table I. The light continuous circles represent the orbits of Saturn, Jupiter, and the Earth, while the heavy one indicates that of planet *U*. Its observed longitudes together with those of the larger planets at the times of maximum perturbation are indicated by connecting lines. Its position in 1932.0 is shown by a short cross line, and its computed longitude in 1831.7 by the letter *c*.

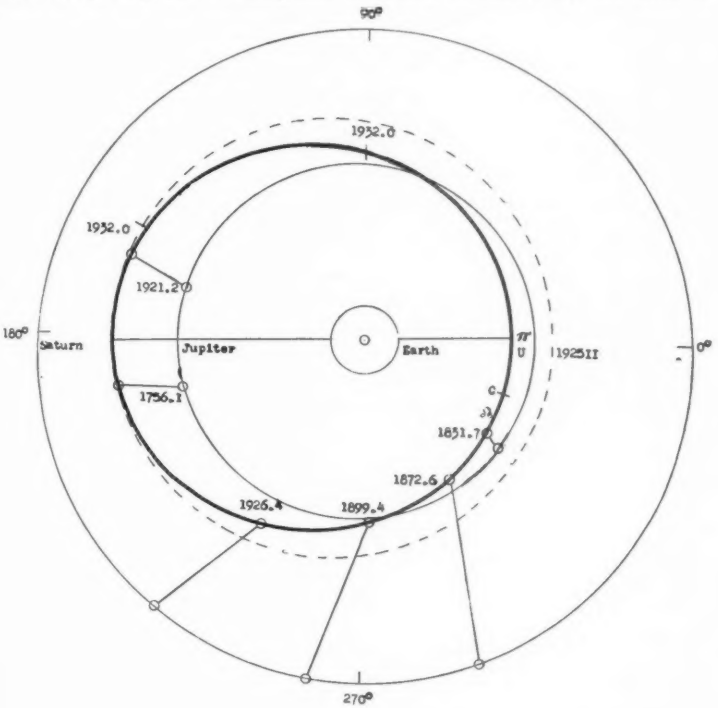


FIGURE 6.
ORBIT OF PLANET *U*.

Its conjunction with Jupiter in that year was an interesting one, particularly so as the conjunctions of these two planets occur only at such long intervals. As seen by Table I the observed longitude of *U* at the time of the maximum displacement was only 1°.5 ahead of Jupiter. The deviation between the observed and the computed longitudes of *U*, however, is very large, 16°. In the year 1756, we see by Figure 6, that *U* was slightly behind Jupiter, but in 1825.7 after five of its revolutions, when it had returned to the same position in its orbit, Jupiter would have been some 45° behind it. However, *U* was near aphelion then, so Jupiter rapidly overtook it, and six years later would have been within

a little more than 16° of it, as we see by Table I, had not their orbits approached so near to one another. Since the inclination of the orbit of *U* is believed to be small, and since Jupiter was outside and only a few million miles away, it was pulling *U* away from the Sun by shifting its orbit, which is the characteristic of the radial perturbation, and so slowing down its orbital speed. This would tend to advance its perihelion, as we have just seen observation indicates. Since *U* was ahead of it, Jupiter was also pulling *U* backwards, with the result that *U* instead of being more than 16° ahead of Jupiter, in 1831.7 was only 1°.5 ahead.

We must now point out that for every 1″ that Jupiter is perturbed, *U* should be displaced 1°.76 if our later assumed value of its mass is correct. Also that at its perihelion *U* is moving 1.44 times as fast as Jupiter, so that through a considerable arc of its orbit, possibly 100°, Jupiter can never overtake *U*, unless due to its own perturbation of it. This is evidently not the time or place to discuss the problem of three bodies, but it is fairly certain that in 1831.7 Jupiter lay within this forbidden arc, and we cannot tell by mere inspection just what took place. It is certain, however, that it did overtake the little planet somewhere about that time. After *U* is found upon a photographic plate, and an accurate orbit has been computed, it will then be possible to determine exactly what happened. I think we may say, however, that the two planets kept pretty close to one another in longitude for a year or two. After 1834 the speed of *U* appreciably diminished and they separated. We notice by Figure 5 that between 1820 and 1832 the displacement of Jupiter increased rapidly, but for the next twelve years until Jupiter got back to the same part of its orbit and the two planets again approached, although Jupiter was now well ahead, its perturbation varied but little. After that it fell off rapidly as *U* pulled it backwards. After six revolutions of *U*, in 1921, the two planets were again in about the same longitude, and as is shown in Figure 6 were in about the same relative position as they had been in 165 years before, during which interval *U* had completed twelve revolutions. The question may now be asked, since Jupiter was outside of *U* in 1831.7, just as Saturn was at the three following conjunctions, why should we not expect a maximum depression as we did with Saturn, rather than a maximum elevation. The explanation is that Jupiter was overtaking *U*, and *U* was pulling it forwards, while when *U* overtook Saturn *U* was pulling Saturn backwards prior to their conjunction. There will be no further conjunction or maximum perturbation of Saturn until after 1950, or of Jupiter until the close of the century, so we must do the best we can with the data now available. Regarding the node of the orbit of *U*, the only information that we have is derived from that planet's effect on the latitudes of Jupiter and Saturn at the times of their maximum deviation by it in longitude. In 1756 Jupiter was deflected 0″.8 to the south, but all the other deflections lie between 0″.0 and —0″.4, and all are confined to longitudes between 160° and 323°. (See the lower curves of Figures 2 and 4.) They

are so few, so small, and so irregularly distributed as we can see by Figure 6, that the only thing that can be learned from them is that, taking their mean longitude as 240°, then the ascending node of the orbit would be near 330°. This result, however, is obviously only approximate, and all the deviations are so small, that we conclude that the inclination of the orbit to that of Jupiter is very slight, perhaps not far from 5°.

The Mass and Magnitude of Planet *U*.

The only object of determining the mass of *U* is to find out how bright the planet should appear on a photographic plate. A considerable difference in mass makes comparatively little difference in magnitude. On account of its analogous orbit we shall select the planet Pluto as an intermediary, and adopt for its mass 0.7 that of the Earth, which cannot be far out of the way. This value was derived directly from the perturbation of Uranus by Neptune amounting to 88″. Pluto produced a maximum perturbation of Neptune amounting to 3″.9, and *U* produced a similar perturbation of Saturn of 1″.5. At the maximum perturbation of Neptune in 1902, Pluto was distant from Neptune by 16.7 units, and similarly at the maximum perturbation of Saturn in 1926, *U* was distant 4.1 units from Saturn. The angular difference in the annual motions of Neptune and Pluto in longitude was 1°.2. This quantity multiplied by the distance of Neptune from the Sun gives us a difference of linear motion of 35.9. Similarly the angular difference in the annual motions of Saturn and *U* at maximum perturbation, 10°.5, multiplied by the distance of Saturn at that time from the Sun is 103.5, given in the same units of distance and time. Whence we derive, since acceleration is directly proportional to distance moved when the times are identical, that the mass of *U* in terms of Pluto is equal to

$$(1''.5 \times 103.5 \times 4.1^2)/(3''.9 \times 35.9 \times 16.7^2) = 0.067.$$

Assuming that their densities are the same, the mass and volume of Pluto will be 14.8 times that of *U*, its surface will be 6.05 times as large, and its diameter 2.46 times as great. The mass of *U* will be 1/21 that of the Earth, 4 times that of the Moon, and 2 times that of Jupiter's third satellite. I have gone into some little detail here, first because as we shall presently see, our final result is somewhat surprising, and I wish that every step should be made clear, and second because I want to show that an approximate computation of the mass, which is all that is needed here, is a very simple matter.

Before we go any further, let us now turn aside for a moment to discuss the probable size and albedo of Pluto, making no assumption at all at first as to its mass. It was stated recently that no successful estimate had been made with the 100-inch reflector as yet of the size of the disk. Let us compare it with the first satellite of Jupiter, conveniently called Io, and with Titan the largest satellite of Saturn. Both of these

satellites vanish when projected on the brightest portions of the disks of their primaries, and we shall therefore call their albedoes 0.50. If Io were removed to the distance of Pluto, the illumination of its disk in 1932.0 would be 1/60 as great. For the same magnification, the 100-inch reflector when freshly silvered, gives 50 times the light of the 11-inch Harvard refractor. If Pluto were of the same angular diameter as Io at the distance of Jupiter, 1″, and of the same albedo, 0.5, with the 100-inch it would be 50/60 as bright, and it would be nearly as easy to measure its disk as it is to measure Io with the 11-inch, but if the albedo of Pluto is the same as the darker maria upon our Moon, let us say 0.05, or 2/3 of the mean albedo, its surface brightness would be reduced to 1/600 of that of Io, and with the 100-inch the brightness of Pluto would be only 1/12 of that of the satellite as seen in the 11-inch. It is quite certain under these circumstances that the disk would not be measurable. Even if its diameter were as great as 1″.5 and a lower magnification were used, it is doubtful if the disk could be measured. In this case its density would be materially less than that of the Earth. Let us now make an analogous computation for Titan. If Pluto were of the same angular diameter as Titan, 0″.6, and of the same albedo, it would be 1/19 as bright, and since the disk of Titan can be measured with the 11-inch, and perhaps could still be estimated, even if it were reduced to 0″.5 in diameter, and since the 100-inch gives 50 times as much light as the 11-inch, the disk of Pluto could easily be measured. By applying a higher power it might theoretically be measured if it were only 0″.3 in diameter. Practically we should perhaps say 0″.4. Since writing the above I have seen a paper by E. C. Bower, *Lick Observatory Bulletin*, **437**, 178, who arrives at somewhat similar conclusions. We thus secure a theoretical range of diameters for the planet. If the albedo of Pluto were 0.50, and it were covered with snow or frozen gas, we might measure its diameter even if it were only 0″.4. Now assuming a mass of 0.7, since the diameter of the Earth at that distance would be 0″.43, Pluto would then be of about the same density. On the other hand if its albedo were only 0″.05 and it consisted of a black meteoric mass with little or no atmosphere, we could only measure it in case its diameter exceeded 1″.5, and its density would then be less than that of Saturn. If its albedo is small, as is probably the case, the chance of measuring its diameter, no matter what its mass might be is very slight. A plausible conjecture is that it is composed largely of meteoric iron, and has a diameter of 0″.4, which will serve us well enough as a basis for computing the diameter of planet *U*.

Having now obtained a definite starting point, and assuming as above computed that the ratio of the masses of *U* and Pluto is as one to 14.8, and the ratio of their surfaces as one to 6.05, then since the orbits of Jupiter and *U* intersect in 1932 at a distance of 5.2 units from the Sun (see Figure 6), and the distance of Pluto in 1930.3 was 41.2, the difference in their magnitudes when in opposition as seen from the Earth

would be 7.3. Accepting the photographic magnitude of Pluto in 1930 as 15.5, then that of *U* becomes 8.2, a surprisingly bright body. At the same time its diameter would be 1″.56. It is thus about half a magnitude fainter than Neptune, and two-thirds of its diameter. The obvious question then at once arises how can it possibly have escaped either accidental visual, or photographic discovery up to the present time. In order to be five magnitudes fainter, it would have to be one thousand times as dense. This is undoubtedly the most serious argument, although a negative one, against its existence. The argument in its favor is positive, and fairly strong, since it is certainly unlikely that five positions, two of them therefore being accidental, should all lie so accurately on one plausible elliptical orbit, particularly so since they are so uniformly distributed along one-half of it. If they were all close together they would tell us little except the period of the planet. Furthermore, in the case of the sixth position, that of 1831.7, Figure 5, marked with the cross, it is shown as we have seen that planet *U* passed very near to Jupiter at this time, and between it and the Sun. These are precisely the two conditions which would most effectively delay the little planet in its orbit, and we find that it was actually delayed for eight months. The deviation amounted to 16° in this case (see Figure 6 C). Turning back again for a moment to Figure 5 we shall notice that the preceding observation in 1830.6 is evidently too low. That of 1822.2, —2″.5 is certainly more than 1″ out of the way, and some of those immediately preceding it in the upper line of the Figure are much worse. If we add 1″, and make the observation of 1830.6 read +1″.0, which may be correct, it will make that year the real maximum, and the deviation in Figure 6 will be reduced to 8°, and the delay of *U* produced by Jupiter be reduced to four months. An error of one year in locating such an early maximum is certainly not unlikely, so that I think we may consider the displacement of this perturbation of Jupiter in the last century to be a further confirmation, rather than an objection to the suggestion of a small and as yet unknown planet revolving between Jupiter and Saturn. Indeed if *U* had not shown some perturbation at the time of its close approach to the great planet, that certainly would have been an objection to the theory of its possible existence. Furthermore it is certain that the perturbations of Saturn are real, since Greenwich and Washington confirm one another, as they do also regarding the last perturbation of Jupiter. No other possible explanation has been offered for them except that of a satellite, and that would not account for the three perturbations of Jupiter. Moreover a photographic search conducted at the Lick and at the Mount Wilson Observatories has hitherto failed to discover *U* as a satellite.

Various explanations have occurred to the writer as to why the planet has not hitherto been found, and which we will now proceed to consider in turn. If an astronomer happened to detect its disk visually, which he could hardly do unless he had an excellent telescope and good seeing,

he would probably pass it by as a rather unusually bright planetary nebula. The failure of its photographic discovery is much more surprising, since it would seem as if it must have already appeared many times on the plates of the asteroid hunters. Its trail at opposition would be of about the same length as that of an ordinary asteroid, greater differential speed with regard to the Earth largely compensating for its greater distance. It would be so much brighter than any expected asteroid that if its burned out elongation were noticed at all on any plate, it would probably be attributed to a moderately close double star. If the stars were taken as trails and the asteroids as dots, *U* would easily be taken for a defect. In case it were noticed on some plate as a possible *nova*, and no other plates were taken within a week of it, it would have moved so far away from its original position, owing to its proximity to the Earth, that the second image might easily have been overlooked, and the first one considered to be a defect. The same conclusion would be reached if it were compared with some standard plate of the region.

Let us now consider the opposite case, in which the planet may be too faint to have been detected. The interesting comet Schwassmann-Wachmann, 1925 II, has an orbit bearing a considerable resemblance to that of planet *U* (see Figure 6). Unlike *U*, however, its orbit lies wholly between that of Jupiter and Saturn. Its eccentricity, **0.142**, is less than that of *U*, its period is slightly greater, 16.30 years, its ascending node is nearly the same, 323°, and its inclination is 9°.43. (*M.N.*, 1929, **89**, 362.) It must be very massive as comets go to be visible at all at such an extraordinary distance from the Sun, and had it approached the latter, would undoubtedly have been a most magnificent object. It was of magnitude 13 to 14 when discovered in 1927, and of magnitude 17 in 1930. On February 11, 1931, it had risen to magnitude 12.5, but in March it had fallen back to magnitude 16.

It must now be pointed out that *U* possesses at present a most dangerous orbit for a solid body. In case it was formerly an outer satellite of Jupiter, with as eccentric an orbit as Jupiter VIII, it might very well, due to a slight increase of the eccentricity, have been drawn out of that orbit into the present one by the combined efforts of Saturn and the Sun. Although they would pull in opposite directions, the pull would be a differential one, and therefore efficient. Although unusual and surprising there would be nothing impossible in this. On the other hand, *U* may never have been a satellite of Jupiter, but merely an errant body flying through space, captured by the Sun, with the coöperation of Jupiter, and caused to settle down into an orbit such as it now possesses. Again it may have been generated at the same time as the other planets, and located at that time in nearly its present orbit. However it originated, after revolving for some eons in that orbit there would occur, as we have just seen in 1831.7, a rather close conjunction with Jupiter near a node. It has been determined that the age of the oldest terrestrial granite is about 2,000,000,000 years. That our planetary system is much

older than that is practically certain, but even so, that interval would give plenty of time for many much closer conjunctions to have occurred than this latter one. In fact they must necessarily have occurred. In case planet *U*, without striking Jupiter, passed near enough to it to fall within Roche's limit, it would be torn in pieces by the great planet, and exist thereafter merely as a swarm of gigantic meteors, or perhaps we might say small asteroids, like Saturn's rings. On account of the considerable mass of *U*, in case this event occurred comparatively recently, let us say within a million years, there would not have been time for the individual pieces to have got very far apart from one another, for example not more than 10,000,000 miles. This distance would measure half a millimeter, or 1/50 of an inch on Figure 6.

If a body of four times the mass of our Moon were scattered along an orbit through a distance of 10,000,000 miles or more, at the distance of Jupiter, it would certainly not be very conspicuous, unless strongly concentrated at its middle section. It therefore seems probable that no large solid body could exist in such an orbit as we have drawn in Figure 6, unless it was relatively speaking a somewhat recent acquisition. If its nature is analogous to Saturn's ring, and it has as high an albedo it might be visible as a faint hazy band resembling a somewhat elongated nebula. Its thickness cannot now be very great, or it would be rapidly distributed along its orbit. Its breadth might be greater without such a distribution taking place. That comet 1925 II may have originally formed a part of this body, perhaps its nucleus, seems fairly probable, and the resemblance of their orbits in some respects may indicate a fairly recent separation. In case, like the comet, *U* possesses a self luminous nucleus, there should be a good chance of finding it. We thus see that we cannot tell whether the planet is actually too bright or

TABLE II.

Elements.		Other Data.	
a Semi-major Axis	5.79	q Perihelion Distance	4.28
e Eccentricity	0.26	Aphelion Distance	7.30
i Inclination	5°±	Distance in 1932.0	5.2
Ω Ascending Node	330°±	Mean Annual Motion	25°.84
π Longitude of Perihelion	1°.8	E Epoch	1932.0
P Period in years	13.93	m Mass	1/22
T Date of Perihelion	1929.7	Photographic Magnitude	8.2
		Angular Diameter	1".56
		Diameter in Miles	3200

Ephemeris of Planet *U*.

Date	H.Long.	Diff.	H.Lat.	Date	H.Long.	Diff.	H.Lat.
1920.0	135°.7	....	+1°.2	1928.0	292°.0	30°.0	−3°.1
21.0	153.7	18°.0	−0.3	29.0	330.5	38.5	0.0
22.0	170.2	16.5	−1.7	30.0	15.5	45.0	+3.6
23.0	186.0	15.8	−2.9	31.0	57.3	41.8	+5.0
24.0	202.0	16.0	−3.9	32.0	90.5	33.2	+4.3
25.0	219.2	17.2	−4.7	33.0	116.2	25.7	+2.8
26.0	238.6	19.4	−5.0	34.0	137.1	20.9	+1.1
27.0	262.0	23.4	−4.6				

too faint to have hitherto been detected, but we at least know now what to look for, and if it can be photographed we shall be less likely to reject its image in the future as a mere defect on the plate.

We have now dealt with all the apparent planetary perturbations that may indicate unknown planets in the solar system, and eliminating planet *T* as doubtful, we find that there are only three, *P*, *S*, and *U*, which still remain to be discovered. There are indeed the two great planets *Q* and *R* described in *Harvard Annals*, **61**, but the latter is doubtful, and the former is not well situated to produce perturbations of the kind described in the foregoing articles, although I may take it up again at some future time. Pluto itself was of course easy to find, and was photographed at once in the predicted place, although not detected until ten years later. It was easy because we knew its longitude within 3° or 4° at the most, and its latitude to the south of the ecliptic by about the same amount (POPULAR ASTRONOMY, 1929, **37**, 138). The latitude of *U* is more uncertain, although it is probably but a few degrees north of the ecliptic at the present time. It is moving much faster than Pluto, which renders its longitude less certain. Its insignificant mass and probable faintness also operate against it. The average overtake period of *U* and the comet is 96 years, and their next conjunction will occur about 1956.7. In case the planet is not identified before then, if it may still be called a planet, that will be a good time to determine its mass, its approximate node, and perhaps the inclination of its orbit, by observations of the changing latitude of the comet. The two bodies will be not far from their ascending nodes.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B.W.I., DECEMBER 3, 1931.

Preliminary Light-Curves of Epsilon^1 and Epsilon^2 Lyrae

By E. A. FATH

During the summer of 1931 the 12-inch refractor of the Lick Observatory was kindly placed at my disposal by Director R. G. Aitken. The program of work decided upon was the study of several of the brighter stars with a photo-electric photometer attached to this instrument. The photometer, as used, consisted of the cell box of the Lick Observatory photometer described by Miss Cummings,[1] a quartz potassium cell by Kunz, a Lindemann electrometer and various minor accessories. All parts of the photometer except the box were taken from the photometer of the Goodsell Observatory.

One of the stars on the observing program was Vega. As comparison stars ϵ^1 and ϵ^2 Lyrae were chosen, since, on the whole, they seemed most

[1] *Lick Observatory Bulletin*, **11**, 99, 1923.

suitable with regard to proximity in the sky, spectral type, and constancy of light. The last consideration was necessarily of the utmost importance. Stebbins[2] had made tests of these stars in two series of measures of nine nights each in 1917 and 1921 respectively in which he measured the difference in magnitude between the two stars. Since the range of the nightly means of this difference in the first series was only 0.014 magnitude and in the second series only 0.024 magnitude it appeared that the probability of constant light was very high.

The observations on Vega were so arranged that they likewise yielded values of the difference in magnitude of the two epsilons, which would thus give a check on the accuracy of the measures on Vega. It soon became evident, however, that there were variations in the value of this difference which bore evidence of periodicity and this persisted as the observations of Vega were continued. Toward the end of July it appeared that at least one of the comparison stars must be variable with a range of the order of 0.02 magnitude.

From that time onward to the middle of August a portion of each night was devoted to measuring directly the difference in magnitude between the two epsilons. By the middle of August it was clear either that both stars were variable or that the measures were far less accordant than previous experience had shown to be probable.

To decide this matter the star ζ Lyrae was then used as a comparison star for the two epsilons as it had been given a good character as regards constancy of light by Stebbins[3] and by Guthnick and Prager.[4] By this time, however, the date of our departure from Mt. Hamilton drew near and we also had several cloudy nights as samples of the unusual California weather of the last summer. In consequence it was possible to compare ϵ^1 with ζ on only five nights and ϵ^2 with ζ on only seven nights while keeping up the remaining part of the observing program.

From these last observations, made from August 13-26, the curves shown in the two figures were obtained. Fig. 1 refers to ϵ^1 with a period of 0.20 day and Fig. 2 to ϵ^2 with a period of 0.0598 day. The range in brightness for both stars is not far from 0.02 magnitude. On no night was there sufficient time to follow ϵ^1 through more than one maximum but on two nights it was possible to follow ϵ^2 through at least two full periods. On the basis of the smaller number of nights on which ϵ^1 was observed and because of the longer period I have less confidence in both curve and period than in the case of ϵ^2.

The photometric elements for the two stars based on this limited observational material are as follows:

ϵ^1 Lyrae Max. = J.D. 2426571.760 + 0.200 E.
ϵ^2 Lyrae Max. = J.D. 2426570.800 + 0.0598 E.

[2] *Pub. Washburn Observatory*, **15**, 90, 1928.
[3] *Pub. Washburn Observatory*, **15**, 91, 1928.
[4] *Vierteljahrsschrift d. A. G.*, **55**, 68, 1920.

Observations to improve these elements will be carried on during the next observing season.

Both of these stars are optical double stars of less than 5″ separation. This prevents a study of the individual stars with the photometer as now constructed. There is, however, some evidence of variation in the radial velocity of each component of each pair. In order to test which component is the possible variable spectrographic observations were begun at the Lick Observatory but they cannot be completed until next season. If one component of each pair can by shown to have a spectrographic period agreeing with the photometric period then the probability that it is also the variable amounts almost to certainty.

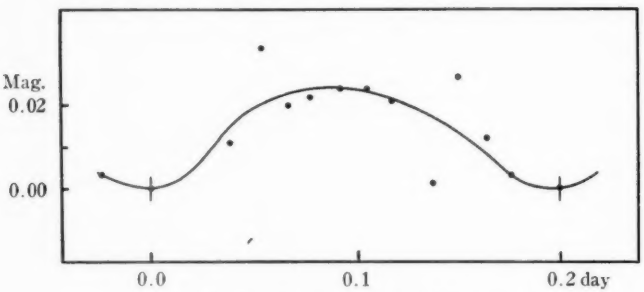


FIG. 1. LIGHT-CURVE OF ϵ^1 LYRAE.

The case of ϵ^2 Lyrae with the short period appears to be of some interest. If my confidence in these results is not misplaced it has the shortest period of a variable star known at present, $1^h\,26^m$.

Assuming a parallax of 0″.014[5] the absolute magnitude of each of the two components of ϵ^2 is about +1. The spectral class is A3. The variable cannot be an eclipsing binary if the curve has any meaning at all. Rotation seems to be out of the question as it would imply an almost impossible mass and the pulsation theory does not seem plausible for so short a period. It occurred to me that possibly outbursts such as are sometimes noted on the sun in the form of eruptive prominences might afford a clue. If we could imagine a series of such eruptions coming from ϵ^2 for a time it would seem to account for the short period, but, the question of the duration of such eruptions might easily be fatal to the hypothesis.

It may be of interest to compare Stebbins' two series of measures of the difference in magnitude between ϵ^1 and ϵ^2 with those of our measures similarly made during last July and early August. His results are published as means for each night, mean for season, etc. Short period fluctuations, if present, are smoothed out by this process.

[5] Schlesinger: *Bright Stars.*

Year	No. of Nights	Mean of Season M	Mean Deviation M	Obsr.
1917	9	0.071	±0.003	S
1921	9	0.070	±0.005	S
1931	14	0.063	±0.004	F

The three series appear comparable as to accuracy but there is a difference of $0^{M}.007+$ in the quantity measured by the two observers. This probably can be accounted for by the differences in the cells used, and, possibly, in the transmission of the telescope objectives so that slightly different portions of the color-sensitivity curve of the cells came into play.

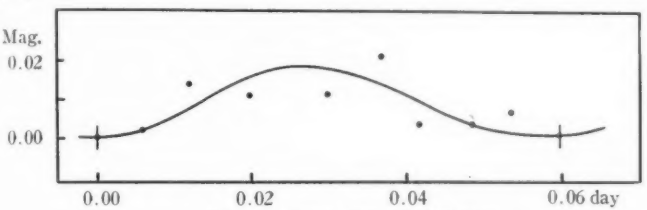


FIG. 2. LIGHT-CURVE OF ϵ^2 LYRAE.

Acknowledgements are due Director Aitken of the Lick Observatory for so kindly placing the 12-inch refractor at my disposal, to President Cowling and members of the Committee on Astronomy of Carleton College for aid in meeting the expenses of the summer's work and to Mr. Conrad Swanson, a student in Carleton College, who acted as volunteer assistant throughout the two months spent at Mt. Hamilton.

GOODSELL OBSERVATORY, NORTHFIELD, MINNESOTA, JANUARY 15, 1932.

Planet Notes for March, 1932

By CLIFFORD E. SMITH

The *Sun* will be moving in a northeasterly direction from the central part of Aquarius to the central part of Pisces. On March 20, at $1^{h}\ 54^{m}$ P.M., C.S.T., the sun will cross the celestial equator from south to north which officially marks the beginning of spring. On March 7 there will be an annular eclipse of the sun.* The path of central eclipse will be just south of Australia. The distance from the earth to the sun will be about 92.0 million miles at the beginning of the month, and this distance will increase about 760,000 miles during the month. The position of the sun on the first and last days of the month will be, respectively:

R.A. $22^{h}\ 47^{m}$, Decl. $-7°\ 45'$; R.A. $0^{h}\ 37^{m}$, Decl. $+3°\ 59'$.

The phenomena of the *Moon* will occur as follows:

New Moon	March 7 at	2 A.M.	C.S.T.
First Quarter	15 "	7 A.M.	"

American Ephemeris, 570, 1932.

Full Moon	March 22	at 7	A.M.	C.S.T.
Last Quarter	28	" 10	P.M.	"
Apogee	10	" 4	P.M.	"
Perigee	13	" 3	A.M.	"

There will be a partial eclipse of the moon on March 22. The beginning will be visible "generally in eastern Asia, Australia, the Pacific Ocean, North America except the northeastern part, and the extreme western part of South America; the ending will be visible generally in Asia except the southeastern part, the Indian Ocean, the Pacific Ocean, and the extreme northwestern part of North America."

Mercury will be moving with an apparent easterly motion from the central part of Aquarius to the eastern part of Pisces. The distance of Mercury from the earth will decrease from about 125 million miles to about 68 million miles, and its apparent diameter will increase from about five to about nine seconds of arc. During the middle of the month it will be an evening star of about magnitude —1, setting about an hour after the sun. Greatest elongation east of the sun (18° 40′) will occur on March 23. Conjunction with the moon will occur on March 8 (Mercury 0°.9 south), and conjunction with Uranus will occur on March 21 (Mercury 2°.9 north). Mercury will pass through its perihelion point on March 16.

Venus will be moving from eastern Pisces to eastern Aries. It will be an evening star of magnitude about —4, and it will set about three hours after the sun. Its distance from the sun will decrease from about 100 to about 80 million miles, and its apparent diameter will increase from about 16 to about 20 seconds of arc. On March 11 it will be in conjunction with the moon (Venus 2° south), and on March 29 it will pass through its perihelion point.

Mars will be near the sun in apparent position. At the end of the month it will rise about forty minutes before the sun.

Jupiter will be an evening star of brightness about magnitude —2 in eastern Cancer. During the middle of the month it will be on the meridian about $9^h\,30^m$ P.M., Standard Time, and, at that time, its distance from the earth will be somewhat greater than 400 million miles, and its apparent diameter will be about forty seconds of arc. Conjunction with the moon will occur on March 19 (Jupiter 3° south).

Saturn will be a morning object of magnitude about +1 in western Capricornus. During the middle of the month it will be on the meridian about 9:00 A.M. Its distance from the earth will be slightly less than 1000 miles, and its apparent semidiameter will be about 14 seconds of arc. Conjunction with the moon will occur on March 3 and March 31 (Saturn 4° north).

Uranus will be near the sun in apparent position since conjunction with the sun will occur early next month.

Neptune will continue in southern Leo near ρ Leonis. Early in the month it will be on the meridian about midnight. Its distance from the earth will be about 2700 million miles, and its apparent diameter will be about 2½ seconds of arc. Conjunction with the moon will occur on March 20 (Neptune 1° south).

CORRECTION to notes on Venus for November, 1931 (October, 1931, p. 468). First sentence should read: Venus will be an evening object, etc. Last sentence should read: During the middle of the month Venus will set about an hour after the sun.

OCCULTATIONS

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

(Contributed by the office of the *American Ephemeris.*)

Date 1932	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Mar. 14	47 B.Aur	6.0	23 25.2	—2.0	+0.3	74	0 49.6	—1.6	—1.5	279
15	354 B.Tau	6.4	5 16.3	0.0	—0.7	67	6 4.2	+0.8	—1.6	301
17	47 Gem	5.6	3 22.0	—0.1	—3.1	152	4 12.2	—1.5	—0.6	245
17	134 B.Gem	6.5	5 48.6	—0.2	—1.3	91	6 42.2	+0.4	—1.7	304
17	4 Cnc	6.2	22 14.2	—1.3	+2.2	70	23 19.6	—1.7	—1.4	316
22	f Vir	6.0	23 44.8	+0.1	—1.5	169	0 21.7	—0.5	+2.1	253
24	550 B.Vir	6.0	1 6.2	+0.2	—0.8	156	1 53.0	—0.7	+1.3	268
25	17 G.Lib	6.4	8 23.8	—1.6	—0.9	116	9 38.2	—1.5	—1.3	296
25	18 G.Lib	6.1	9 2.3	—1.5	—1.1	121	10 14.5	—1.3	—1.4	286
26	b Sco	4.7	10 25.6	—1.5	0.0	49	11 9.3	—1.6	—2.4	338
27	135 B.Sco	6.0	6 2.5	..	..	194	6 8.3	..	..	204
30	ω Sgr	4.8	8 52.1	—1.5	+1.9	55	10 3.9	—1.6	+0.7	285

OCCULTATIONS VISIBLE IN LONGITUDE +91°, LATITUDE +40°.

Date 1932	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Mar. 14	47 B.Aur	6.0	22 44.7	—2.1	+1.2	75	0 16.0	—2.2	0.0	264
15	354 B.Tau	6.4	5 17.7	—0.1	—1.4	97	6 16.7	+0.2	—1.3	272
17	134 B.Gem	6.5	5 47.8	—0.3	—1.9	122	6 48.3	—0.3	—1.4	276
22	31 B.Vir	6.4	10 22.8	—0.1	—2.7	180	10 54.1	—0.7	—0.9	245
25	17 G.Lib	6.4	7 59.9	—1.0	—0.9	146	9 8.7	—2.0	—0.4	277
25	18 G.Lib	6.1	18 38.8	—1.2	—1.1	146	19 46.8	—2.0	—0.6	273
26	b Sco	4.7	9 44.8	—2.4	+0.5	68	10 45.0	—1.5	—1.6	332
26	4 Sco	5.7	12 17.4	—1.5	—1.3	112	13 27.0	—1.0	—1.2	269
30	A Sgr	4.9	10 5.7	—1.4	+1.6	73	11 25.3	—1.7	+0.9	266

OCCULTATIONS VISIBLE IN LONGITUDE +120°, LATITUDE +36°.

Date 1932	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Mar. 2	234 B.Sgr	5.9	14 6.0	—1.8	+1.1	86	15 31.5	—2.2	+0.7	259
15	354 B.Tau	6.4	5 26.7	..	..	160	5 57.3	..	..	209
20	34 Leo	6.4	7 39.6	—2.1	—0.7	93	8 38.6	—0.2	—2.6	343
26	b Sco	4.7	8 51.4	—0.9	0.0	125	10 3.2	—1.6	+0.1	289
26	4 Sco	5.7	11 29.8	—1.7	—0.8	131	12 46.2	—2.2	—0.5	270
26	π Sco	3.0	13 38.9	..	..	28	13 59.8	..	..	358
28	W Sgr	4.3	12 32.1	—2.2	+0.5	88	13 59.6	—2.3	—0.2	274
29	183 B.Sgr	6.2	13 8.7	—2.1	0.0	117	14 19.6	—2.1	+1.2	225

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The annual report for the American Meteor Society is being published a month earlier than usual. This undoubtedly will mean that some observers who are slow about sending in their last records will have a smaller total than they deserve, but it seems wise not to delay the report longer. The tables which follow will exhibit briefly the great success that attended the work in 1931.

Tables I and II are similar; the first is for members, the second for persons reporting as do our members but who have not formally joined the Society. In both are given the name and station of the observer, the number of nights on which regular observations were made, and the number of meteors recorded. Of the meteors in Table I, probably 70 per cent were mapped and recorded in full, as well as counted; in Table II, a much smaller per cent was mapped. Both groups worked under the general instructions issued by the A.M.S., so there is considerable uniformity in procedure as well as in records. Table III lists telescopic meteors, all observed as to date, time, region, and magnitude. Fortunately more than half have the position angle of flight also given. This last datum doubles the value of the observation. Doubtless other lists will arrive too late for inclusion. It is still a matter of much regret that we cannot interest more people, especially variable star observers, in this important field, for the labor involved is almost nothing, no one seeing many telescopic meteors in the course of any one year. We will gladly furnish the proper blanks and instructions to persons willing to use them.

Finally we give the summary of the meteors reported by volunteers for the Perseid and Leonid epochs, and the number of bright meteors and fireballs reported. Full details of the Perseid counts will be found in "Meteor Notes" of October and November, 1931, and of the Leonid counts in those of December, 1931, and January, 1932. It is quite impracticable to repeat here the name of every observer. We have not included in our totals the counts by the Mid-Western Meteor Association, of which Professor C. C. Wylie is director, though they kindly send us copies of their work for our files, as these have already been published under his auspices. Also none of the counts from ships, usually given only in approximate numbers, has been added for the Perseid and Leonid epochs. These latter would probably amount to a thousand meteors. The reports on fireballs and bright meteors include those most valuable ones passed on to us by the U. S. Weather Bureau and the Hydrographic Office, U.S.N., from ships at sea. They also include those brilliant objects (counted of course as only one each in the total) for which we have collected anywhere from two to nearly a hundred observations each. Such objects will form the subjects of special investigations.

Glancing at the sum total, it will be seen that 1931 doubled the amount of work reported for 1930, which had been our best year up to date. This shows a healthy and growing interest in meteoric astronomy. In fact, it is quite impossible to tell exactly how many persons did contribute to this report, but the number runs well towards a thousand. The daily press also gave us full support in our efforts to reach the intelligent public. The A.M.S. may enter 1932 feeling that this work has fully justified our most sanguine expectations.

We welcome these new members:

W. J. Persons, R.R. 6, Kalamazoo, Michigan.

M. Geddes, Otekura, Otago, New Zealand.
R. E. Clark, Carleton College, Northfield, Minnesota.
Theodore Pollock, Guilford College, North Carolina.
Miss Alice Braden, 302 Odette Street, Flint, Michigan.
H. L. Bowman, 138 South Pugh Street, State College, Pennsylvania.
G. A. Mulheron, 309 Ash Street, Winnipeg, Manitoba, Canada.
O. C. Bobbitt, Weather Bureau, Brownsville, Texas.
J. I. Wakefield, Greenville, Texas.
J. H. Pruett, Box 185, Eugene, Oregon.
Mrs. J. H. Pruett, Box 185, Eugene, Oregon.
Wesley Simpson, 639 Lockley Place, Webster Groves, Missouri.
Miss M. F. Schreiber, 812 S. Coronado St., Los Angeles, California.

Reprint No. 12 of the Flower Observatory, containing the Meteor Notes for 1931 and two articles on fireballs, one of these latter the joint work of O. E. Monnig and the writer, has been partly distributed. Any member who has not received his copy will please notify us. Notice is also given that the annual dues for 1932 should be sent in. Persons who joined after September 1, 1931, will not have to pay dues until January 1, 1933.

At the request of the Hydrographic Office, U.S.N., the writer wrote an article entitled "Methods for Computing the Heights and Paths of Fireballs and Meteors," which has been printed on the back of one of their pilot charts. This gives three methods. The chart may be ordered direct from the Hydrographic Office, U.S.N., Washington, D. C. Members interested in this problem are advised to get it.

The University authorized the addition of a day assistant to our staff, largely to aid in catching up with the meteor work, which was more than the writer could possibly handle alone in addition to his other duties. Since September this position has been most efficiently filled by Mrs. Doris M. Wills, and we are already beginning to bring many pieces of work nearer conclusion. In fact, several papers now await publication, and we hope from now on to keep our reductions more up to date.

TABLE I.

Name	Station	Nights	Meteors
Abernathy, C.	Clearwater, Florida	34	231
Alpha Nu Fraternity, α Chapter	Boulder, Colorado	2	846*†
Alpha Nu Fraternity, β Chapter	Denver, Colorado	4	356*†
Bobbitt, O. C.	Brownsville, Texas	9	414*
Burns, H. A.	Spring Valley, New York	3	33
Claridge, G. C.	Reedsburg, Wisconsin	..	259
Conboy, J. J.	Lawton, Oklahoma	1	60
Darling, B. C.	Lansing, Michigan	48	353
Dartayet, M.	La Plata, Argentine	4	62*
Dawson, B. H.	La Plata, Argentine	4	82*
Edwards, Mrs. W. H.	Fairhope, Alabama	3	518*
Evons, M. L.	Drexel Hill, Pennsylvania	1	22
Ford, C. B.	Ann Arbor, Michigan	7	85
Gardner, R. F.	Lakewood, Ohio	..	21
Geddes, M.	New Plymouth, New Zealand	42	866
Gell, K. E.	Rochester, New York	1	710*
Kingsbury, J. A.	Ulster County, New York	2	22
La Paz, L.	Columbus, Ohio	12	151

* Count or largely count.
† Probably some duplication.

Name	Station	Nights	Meteors
MacQueen, J. W.	Birmingham, Alabama	18	129
Marsh, F. F.	Frederick, Maryland	3	32
McIntosh, R. A.	Aucklanu, New Zealand	13	196
McKee, J. E.	Bellville, Ohio	8	58
Mehl, M.	Fort Worth, Texas	4	57
Monnig, O. E.	Fort Worth, Texas	19	278
Nininger, H. H.	McPherson, Kansas	2	296*
O'Byrne, S. L.	Webster Groves, Missouri	10	164
Olivier, C. P.	Flower Observatory, Pa. Ulster County, New York	2	284
Persons, W. J.	Kalamazoo, Michigan	14	399
Reich, E. R.	Marshfield, Wisconsin	2	111
Ridley, G. W.	Alameda, California	33	581
Sanders, B.	Fort Worth, Texas	2	35
Scudder, W. F.	Wellsboro, Pennsylvania	1	52
Smith, F. W.	Glen Olden, Pennsylvania	49	203
Tomkins, T. K.	North Hills, Pennsylvania	8	37
Trimmier, Miss M. E.	Chicago, Illinois	4	142
Troyer, F. L.	Toronto, Canada	2	280
Urquhart, Miss S.	Detroit, Michigan	7	82
Wamer, W. P.	Upper Darby, Pennsylvania	4	115
Whitney B. S.	Norman, Oklahoma	2	134
Williams, J. D.	Tunkhannock, Pennsylvania	31	722
Ten members reporting less than 20 each			86
		Total	9564

TABLE II.

Name	Station	Nights	Meteors
Baker, S. R.	York, Pennsylvania	2	54
Brayton, A. M.	Pasadena, California	3	125
Clarke, R. G.	Franklin, Pennsylvania	1	50
Ensign, M. R.	Gainesville, Florida	1	404*
Harbutt, R. G.	Penney Farms, Florida	..	30
Maria Mitchell Observatory	Nantucket, Massachusetts	1	35*
McLeod, N. W.	Christine, North Dakota	1	30
Munoz, J. L.		6	95
Simpson, W.	Webster Groves, Missouri	13	262
Texas Group Volunteers	Fort Worth, Texas	7	693
Watson, P. S.	Baltimore, Maryland	1	26
Webster Groves Volunteers	Webster Groves, Missouri	10	642*
		Total	2446

TABLE III.

TELESCOPIC METEORS.

Name	Station	Meteors
Bouton, T. C. H.	St. Petersburg, Florida	5
Darling, B. C.	Lansing, Michigan	3
Dawson, B. H.	La Plata, Argentine	30
Flower Observatory	Upper Darby, Pennsylvania	15
Ford, C. B.	Ann Arbor, Michigan	23
Jones, E. H.	Goffstown, New Hampshire	6
Marsh, F. F.	Frederick, Maryland	16
Peltier, L. C.	Delphos, Ohio	48
Smith, F. W.	Glen Olden, Pennsylvania	5
	Total	151

Perseid Epoch	13,667
Leonid Epoch	2,940
Fireballs	245

Grand Total of all meteors reported for 1931, with a few not included in 1930 report:

Table I	9,564
Table II	2,446
Table III	151
Perseid Epoch	13,667
Leonid Epoch	2,940
Fireballs	245
Grand Total	29,013

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1932, January 16.

The 1932 Return of the Leonid Meteors

By C. C. WYLIE

One of the earliest investigations of the period of the Leonid meteors was published by H. A. Newton in 1863, who then ventured to predict the great display seen in November, 1866. A similar study has recently been published by V. Maltzev of Tashkent, U. S. S. R. (Russia) in *The Observatory*, **54**, 297-299. From a discussion of past appearances he finds a secular decrease in the period, and from the formula derived, he finds "the most probable moment of the crossing of the orbit of the earth by the meteoric stream is 1932.92," or about December 2, 1932. From the observed positions of the node of the Leonids, he derives the following formula for the longitude:

$$\text{Longitude} = 232^\circ\ 41'.6 + 1'.728\ (T - 1900).$$

From this formula he calculates for the years 1931 to 1935, inclusive, the moment of most probable maximum. Universal, or Greenwich Civil Time, is used. The display of 1901 is the latest included in this investigation.

Stoney and Downing found that perturbations of the Leonid stream by Jupiter, Saturn, and Uranus may cause an oscillation from the mean value of the rate of advance of the node, so that the shower may be a day ahead of, or behind a prediction based on the mean rate. The writer has, therefore, compared the recent appearances of 1928-1931 with the times as predicted by Maltzev's formula. The Central Standard Time of the earth's reaching the node was computed and compared with the hour of best display as estimated from the available observations for each of these years.

For fixing the maximum in 1928, the observations reported by the Observatorio Nacional, Tacubaya, Mexico, are the most complete. Counts are highest on the night of November 15 just before dawn, and from 14^h to 15^h, more meteors were seen on November 16 than on November 14. This suggests that the actual maximum occurred after dawn on the 15th. We have adopted $15^d\ 17^h$, 105th meridian time, or November $15^d\ 18^h$ Central Standard Time. Other reports agree satisfactorily with this estimated time of maximum.

The maximum in 1929 is poorly determined, as there are no available counts by the same observer extending over the essential dates, and clouds prevented any observations in England. Counts at Dubuque, Iowa, and Iowa City, Iowa, indicated that the display was better on November 15 than on November 14. The only available report covering both November 15 and November 16 is that from the Maria Mitchell Observatory. This indicates there were more Leonids from

13^h to 14^h on the later date. The number, however, is less than that observed by a group of the same size from Blue Hill Observatory on November 15. We have assumed that the maximum occurred about half-way between these observations on the 15th and 16th, or at November $16^d\ 3^h$, Central Standard Time.

For 1930, more observations are available. J. P. M. Prentice reports several English counts of the Leonid meteors. The estimated rate as dawn approached, about 12^h Central Standard Time, was 80 per hour, and obviously increasing. At Iowa City, the count for one observer rose to 100 per hour at $15^h\ 15^m$ when clouds caused a drop. It cleared again and the rate rose to 123 per hour for one observer at $17^h\ 30^m$, but there were fewer brilliant meteors than before clouds interfered. At Tacubaya, Mexico, the highest count was reached for the half hour from $16^h\ 00^m$ to $16^h\ 30^m$ (approximately 3:30 A.M. to 4:00 A.M. Tacubaya local time). From the Tacubaya counts, one might assume that the real maximum was reached by 16^h, as the increase in altitude of the radiant should cause some increase in the count. The highest count reported by any single observer was made at Iowa City just before dawn, but spectacular meteors were most numerous at about $15^h\ 45^m$, three leaving ten-minute trails, and it is reasonable to assume that except for the clouds, and the lower altitude of the radiant, the count would have been higher. We have adopted November $16^d\ 15^h\ 30^m$ as the moment of maximum.

Some reports on the 1931 Leonid meteors are now available from England, from various parts of the United States, and from Honolulu. Unfortunately, clouds interfered in each of these places on November 16, the night of the maximum. Mr. Prentice was stopped by clouds at $3^h\ 30^m$ A.M., the estimated rate being then 25 per hour. The most complete counts available were made by two groups in New York state, at an altitude of more than 2000 feet, Professor Olivier being with one of the two. These show the highest count for the hour 15^h to 16^h, Central Standard Time, or just before dawn in New York state. At Cleveland, an hour west, Professor Nassau also found the count highest just before local dawn. At Auburn, Alabama, Professor Hampton saw a spectacular display, after the rate in New York had dropped. The report from the Steward Observatory, Tucson, Arizona, and Dr. Merrill's count from Las Vegas, Nevada, indicate that the display was spectacular some three hours after dawn in New York. First reports from Honolulu indicate the display was not so spectacular there, but clouds interfered. The counts of Father Theobald at Dubuque, Iowa, on the 15th and 17th suggest that the maximum was nearer the observations of the second date. From these considerations we have adopted November $16^d\ 18^h$ as the moment of maximum in 1931.

The following table gives for the years 1928 to 1931, inclusive, the times adopted in the preceding paragraphs from actual observations, the moment of maximum as computed from the formula, and the derived corrections.

Year	Observed Maximum	Computed Maximum	Correction O — C
	d h	d h	h
1928	Nov. 15 18	Nov. 15 08	+10
1929	16 03	15 14	+13
1930	16 15½	15 21	+18½
1931	16 18	16 04	+14

Averaging the last column we obtain $+14^h$ as the correction to Maltzev's ephemeris. The following table gives the computed time of maximum, the time with the correction added and the age of the moon, for the Leonid maxima of 1932 to 1935, inclusive. Central Standard Time, and noon-to-noon reckoning, is

used.

Year	Computed Maximum d h	Corrected Maximum d h	Age of Moon Days
1932	Nov. 15 11	Nov. 16 01	18
1933	15 17	16 07	28
1934	15 23	16 13	9
1935	16 06	16 20	21

The corrected time of maximum falls in 1932 in the early afternoon of November 16 for persons in the Eastern and Central time belts. This indicates the early morning of November 16 (Civil Time) should be the time of best display in the United States. According to this prediction, Americans will miss the most spectacular shower. It will be witnessed in the early morning hours of November 17 (Civil Time) by residents of Japan, Korea, China, and the Philippines. Australia is rather far south, but should get an excellent view. The brilliant moon, only three days after full and 28° north declination, will greatly cut down the number of meteors visible.

Mr. Maltzev finds, as we have stated, that the nucleus of the meteoric stream crosses the earth's orbit about December 2, 1932. If this be correct, the shower of 1932 should be the most spectacular of this series; but perturbations may well alter the date by several months. From a study of the perturbations of Tempel's Comet, the associated comet, Crommelin concludes that the date of perihelion is uncertain by months, but he adopts November 1, 1932, as the probable date, with the comet passing the node 5½ days after. Also the comet passes half a million miles closer to the earth's orbit than in 1899.

To summarize—The recent excellent displays of Leonid meteors, the investigation of the orbit of Tempel's Comet by Crommelin, and the study of the period of the Leonids by Maltzev all encourage us to hope for a spectacular display in November, 1932. The investigation of the present position of the node from the displays of 1928-1931, however, indicates that the Japanese and Chinese have the best chance of seeing a wonderful shower such as Americans saw in 1833. Our result is that Americans will see the advance guard in the morning hours of November 16, and the rear guard after 11:00 o'clock on the following night, the real shower being seen over Australia, China, Japan, and the Philippines in the morning hours of November 17.

University of Iowa, January 19, 1932.

Variable Stars

Monthly Report of the American Association of Variable Star Observers for December, 1931

The weather conditions during the interval covered by this report have been very inclement, as indicated by the meagerness of the reports from almost every section. Eastern United States appears to have fared better than most places, as evidenced by the reports from New Hampshire, Ohio, and a few other locations.

We are grateful to Professor J. C. Duncan of the Wellesley College Observatory for communicating a valuable set of observations by one of his students, Miss

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

Oct. 0 = J.D. 2426615; Nov. 0 = J.D. 2426646; Dec. 0 = J.D. 2426676.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V Scl	T Cas	U Cas	U Tuc	RU And	T Per
000339	001755	004047a	*005475*	013238	021258
645 13.6 En	678 8.5 Mc	663 9.3 Hu	638 9.9 Bl	659 11.7 Pt	650 8.7 Ah
S Scl	678 8.9 Me	668 9.3 L	645 9.5 En	668 12.6 L	650 8.5 Jo
001032	688 8.6 Al	671 9.0 Hu	647 9.2 Sl	678 13.6 Ma	655 8.5 Jo
628 7.7 Bl	R And	672 9.7 Bw	Z Cet	Y And	658 8.5 Jo
638 7.0 Bl	001838	674 9.6 Md	*010102*	013338	659 8.8 Pt
645 7.4 En	656 12.0 Ch	676 9.1 B	659 11.4 Pt	663[12.4 Hu	666 8.6 Bo
659 7.3 Pt	659 11.4 Pt	677 9.3 Hu	668 9.8 L	674[14.4 Br	677 8.9 Bo
X And	677 9.9 Hu	677 9.3 Me	U Scl	678[12.6 Ma	678 8.7 Bo
001046	678 9.9 Ma	678 9.3 Sf	*010630*	X Cas	681 8.7 Bo
672[13.2 Bw	683 9.8 Hu	683 9.4 Hu	628[13.2 Bl	014958	o Cet
681[13.4 Bw	690 9.5 Hu	690 9.9 Hu	U And	650 10.4 Jo	*021403*
691[13.4 Bw	S Tuc	690 10.1 Sf	010940	653 10.0 Jo	621 7.9 Sl
T Cet	*001862*	691 10.4 Bw	663 12.6 Hu	655 10.0 Jo	628 8.0 Sl
001620	621[14.0 Sl	692 10.3 Me	*667* 11.7 Hu	657 10.2 Jo	636 8.5 Lv
677 6.5 L	628[13.2 Bl	— Cas	668 11.8 L	658 10.1 Jo	637 8.2 Sl
T And	645[13.2 En	004047b	674 11.4 Br	659 10.9 Pt	645 8.8 En
001726	S Cet	659 10.4 Pt	683 11.0 Hu	666 10.1 B	647 8.5 Sl
644 8.8 Ch	*001909*	RW And	690 10.7 Hu	668 10.0 Jo	648 9.0 Ah
648 8.8 Th	645 8.9 Ch	004132	UZ And	672 9.9 Jo	649 8.6 Si
648 8.4 Jo	652 8.5 Jo	673 12.9 Br	011041	683 11.5 Bn	650 9.0 Ah
651 8.3 Jo	655 8.7 Jo	690 11.1 Hu	668 10.8 L	U Per	650 8.6 Jo
653 8.2 Jo	656 9.0 Ch	V And	678 11.3 Ma	015254	651 9.1 Ah
657 8.1 Jo	657 8.7 Jo	004435	691 12.5 Bw	645 8.4 Ch	651 9.1 Mn
658 8.1 Jo	658 8.8 Jo	673[13.6 Br	S Psc	647 8.6 Ry	652 8.6 Lv
659 8.6 Pt	659 8.9 Pt	674[14.4 Br	011208	650 8.7 Jo	655 8.7 Jo
662 8.1 Hu	663 8.4 Hu	X Scl	674 13.6 Br	653 8.6 Jo	656 9.3 Ah
663 8.0 Hu	671 9.4 Hu	*004435*	S Cas	653 8.6 Ry	658 8.7 Jo
667 8.7 Th	672 9.2 Jo	628[13.0 Bl	011272	655 8.4 Jo	659 9.1 Cy
671 8.2 Hu	676 9.4 Jo	RV Cas	653 11.0 B	657 8.3 Jo	659 8.9 Lv
672 8.0 Jo	677 10.0 Hu	004746a	653 10.6 Jo	658 8.4 Ry	659 9.0 Pt
674 8.3 Md	677 9.6 L	659 13.4 Pt	655 10.5 Jo	659 8.2 Pt	662 9.5 Mn
676 8.1 Jo	678 10.0 Sf	674 11.7 Br	656 10.8 Ch	663 8.7 Bo	662 9.0 Ch
677 8.2 Hu	683 10.1 Sf	W Cas	657 9.9 Jo	666 8.5 Bo	666 9.0 Sa
683 9.3 Hu	690 10.5 Sf	004958	658 9.8 Jo	666 8.1 B	666 9.0 Bo
687 8.7 Hu	690 10.4 Hu	648 11.3 Jo	666 9.2 B	675 8.3 Mc	668 8.9 L
690 8.6 Hu	T Scl	652 10.8 Jo	668 9.0 Jo	676 8.0 Jo	671 9.1 Cy
691 8.5 Me	*002438a*	655 10.4 Jo	670 9.1 B	676 8.5 B	672 8.8 Jo
T Cas	645 9.4 En	657 10.2 Jo	676 9.0 B	677 8.2 Bo	672 9.0 Lv
001755	T Phe	658 9.9 Jo	676 8.7 Jo	678 8.0 Bo	676 9.1 Jo
644 9.9 Ch	*002546*	659 11.1 Pt	691 8.8 Me	678 8.5 Mc	676 9.2 Wd
648 10.1 Th	624 14.1 Sl	660 10.6 B	U Psc	681 7.9 Bo	677 9.3 Bo
648 9.4 Jo	628[13.2 Bl	666 10.7 Bo	011712	XX Per	678 9.1 Bo
649 9.4 Mn	645[13.0 En	668 9.9 Jo	659 13.0 Pt	015654	678 9.3 Ma
651 9.3 Jo	W Scl	672 9.7 Jo	RZ Per	645 8.0 Ch	678 9.3 Sf
653 9.4 Jo	*002833*	672 10.5 Bw	012350	S Ari	678 9.0 Lv
655 9.2 Jo	628 13.1 Bl	677 10.6 Bo	656 10.0 B	015912	678 9.2 Cy
657 9.6 Jo	645 13.0 En	678 10.5 Bo	668 9.3 L	674[14.3 Br	680 9.1 O
658 8.7 Jo	Y Cep	681 10.4 Bo	681 10.0 Md	R Ari	680 8.7 Sa
658 9.1 B	003179	681 10.6 Bw	R Psc	021024	681 9.1 Bo
658 9.2 Mn	673[13.9 Br	688 10.5 Al	012502	658 12.7 B	681 9.3 Wd
659 8.9 Pt	U Cas	691 10.5 Bw	648 8.5 Ah	659 13.2 Pt	681 9.2 Cy
661 9.0 Th	004047a	U Tuc	649 8.6 Ah	674 11.8 Br	705 8.9 Pk
668 8.6 Jo	653 9.4 Jo	*005475*	650 8.5 Ah	678 12.0 Ma	705 9.0 C
672 8.5 Jo	655 9.2 Jo	621 11.0 Sl	651 8.6 Ah	W And	S Per
675 8.4 L	658 9.0 Jo	628 10.3 Sl	656 8.6 Ah	021143a	021558
675 8.4 Mc	659 8.9 Pt	628 10.4 Bl	656 8.5 Ch	645 11.4 Ch	650 9.5 Ah
676 9.5 Mn	662 9.1 Hu	637 9.9 Sl	659 8.3 Pt	659 12.0 Pt	652 9.2 Sz

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

S PER
021558
659 10.4 Pt
666 9.8 Bo
677 10.0 Bo
677 10.3 Me
678 10.1 Bo
681 10.0 Bo

R CET
022000
645 10.9 Ch
650 10.2 Jo
653 10.0 Jo
655 9.9 Jo
656 9.8 Ch
658 9.0 Jo
668 8.8 L
675 8.2 Jo
678 8.4 Sf
683 8.4 Sf
688 8.3 Bg

RR PER
022150
645 10.3 Ch
659 10.3 Pt
660 9.6 B
675 11.3 L

R FOR
022426
628 11.4 Bl
638 10.5 Bl

U CET
022813
650 8.2 Th
655 7.5 Jo
656 7.2 Ch
659 7.6 Pt
668 7.1 L
676 7.0 Jo

R TRI
023133
645 11.3 Ch
648 10.8 Ah
650 11.2 Ah
650 10.9 Jo
655 11.0 Jo
657 11.3 Jo
658 11.4 Jo
658 11.5 Ah
659 11.0 Pt
676 11.5 Jo
678 11.5 Sf
678 11.4 Ma
683 11.7 Sf
705 10.5 Pk
705 10.6 C

T ARI
024217
650 8.9 Jo
655 9.2 Jo

T ARI
023217
658 9.2 Jo
671 9.4 Jo
676 9.4 Jo
677 9.9 Me
682 9.9 Me
692 10.2 Me

W PER
024356
645 10.8 Ch
647 10.9 Ry
650 10.0 Jo
653 10.2 Jo
653 11.0 Ry
653 10.3 B
655 10.6 Jo
656 10.5 B
656 10.7 Cy
657 10.6 Jo
658 10.8 Jo
658 11.0 Ry
659 11.0 Pt
666 10.8 B
669 11.2 Cy
670 10.6 B
672 10.0 Jo
675 9.7 Mc
676 10.0 Jo
676 10.6 B
677 9.9 Mc
678 10.3 Cy
679 11.5 Me

R HOR
025050
621 10.9 Sl
637 11.1 Sl
638 11.0 Bl
645 11.8 En

T HOR
025751
621 12.1 Sl
628 12.4 Sl
637 13.0 Sl
638 13.0 Bl
646 13.0 En
647 13.1 Sl

U ARI
030514
663[12.3 Hu
677[13.2 Hu
683[12.6 Hu
687[13.1 Hu

X CET
031401
649 9.0 L
653 9.3 Jo
655 8.7 Jo
656 9.4 Ch
658 8.7 Jo

X CET
031401
659 8.8 Pt
675 8.0 Jo
677 9.0 Hu
678 9.3 Sf
683 9.4 Sf
683 9.1 Hu
690 9.4 Sf

Y PER
032043
648 10.4 Ah
650 10.4 Ah
650 9.6 Jo
653 9.7 Jo
655 9.9 Jo
656 10.4 Ch
657 10.4 Ah
657 9.9 Jo
658 9.8 Jo
659 10.0 Pt
666 10.4 Bo
668 10.0 Jo
675 10.2 Mc
676 10.4 Jo
677 10.1 Mc
678 10.7 Bo
681 10.8 Bo

R PER
032335
645 8.8 Ch
650 8.6 Jo
653 8.7 Jo
655 8.7 Jo
659 9.1 Pt
660 8.9 B
668 8.8 L
676 9.0 Jo
678 8.9 Ma

NOV PER
032443
659 13.2 Pt

U ERI
034625
646 9.5 En

T ERI
035124
646 9.5 En

R TAU
042209
659 12.6 Pt
662 13.0 Ch
678 13.2 Ma
683 12.5 Hu
687 12.0 Hu
690 12.4 Hu

W TAU
042215
655 10.1 Jo
657 10.5 Jo
659 10.1 Cy
659 10.0 Pt
662 10.0 Ch
668 10.4 L
675 10.4 Jo
676 10.0 B
678 10.2 Cy
680 10.9 O
680 10.9 Sa
692 10.0 Bw

S TAU
042309
659 13.3 Pt
661 13.0 Ch
678 13.6 Ma

T CAM
043065
649 8.6 L
650 8.4 Jo
653 8.5 Jo
655 8.7 Jo
657 8.7 Jo
658 8.8 Jo
659 9.1 Pt
661 9.1 Ch
666 9.3 Bo
668 8.9 Jo
675 9.3 Jo
677 9.2 L
678 9.6 Bo
681 9.6 Bo

RX TAU
043208
649 12.6 L
661 13.0 Ch
677 13.5 L

R RET
043263
621 9.2 Sl
628 8.6 Sl
638 7.6 Sl
638 7.8 Bl
646 7.2 En
647 7.1 Sl

X CAM
043274
649 10.1 L
655 8.6 Jo
657 8.2 Jo
658 8.5 Jo
659 9.5 Pt
676 8.2 B
677 7.9 L

R DOR
043562
621 5.0 Sl

R DOR
043562
628 4.9 Sl
637 5.0 Sl
638 5.5 Bl
646 5.2 En
647 5.1 Sl

R CAE
043738
638 7.1 Bl
646 7.7 En

R PIC
044349
638 7.2 Bl
646 7.7 En

V TAU
044617
656 9.8 Ch
658 9.9 Jo
659 9.9 Pt
676 12.3 Jo

R ORI
045307
675 9.3 L
676 9.5 Wa
681 10.0 Sf

R LEP
045514
624 7.0 Sl
637 7.0 Sl
651 7.1 Jo
655 7.0 Jo
658 7.0 Jo
659 6.8 Pt
661 5.2 Si
668 6.6 Jo
675 7.2 L
678 7.4 Ma

V ORI
050003
649 13.6 L
659 13.4 Pt
687 12.6 Hu
690 12.5 Hu

T LEP
050022
638 10.4 Bl
651 11.5 Jo
655 11.0 Jo
659 11.0 Pt
668 10.7 Jo

S PIC
050848
638[12.2 Bl
646[12.9 En

R AUR
050953
648 7.7 Ah
649 7.6 Ah
649 7.6 Mn

R AUR
050953
650 7.5 Ah
650 7.6 Jo
651 7.6 Ah
653 7.7 Jo
655 7.5 Jo
656 7.5 Ah
657 7.5 Ah
657 7.5 Jo
658 7.6 Jo
658 7.5 Ah
659 7.0 Pt
663 7.5 Mn
667 7.5 Ah
668 7.3 Jo
668 7.5 Ch
669 7.7 Wd
671 7.3 Jo
676 7.4 Jo
676 7.9 Wd
676 7.9 Wa
688 7.7 Bg

T PIC
051247
638 8.3 Bl
646 8.8 En

T COL
051533
638 9.0 Bl
646 9.5 En

S AUR
052034
650 8.7 Jo
653 8.8 Jo
655 8.9 Jo
657 8.9 Jo
658 8.8 Jo
659 8.6 Pt
666 10.1 Bo
668 10.5 Ch
675 9.3 Jo
677 9.3 Mc
678 10.6 Bo
681 10.6 Bo

W AUR
052036
649 12.3 L
655 11.6 Jo
658 11.0 Jo
668 11.4 Ch
675 9.7 Jo
676 10.5 Wa
677 10.2 L
678 9.8 Ma
681 9.2 Sf
690 8.6 Sf

S ORI
052404
655 10.4 Jo

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
S ORI	U AUR	U ORI	AG AUR	R GEM	T GEM
052404	053531	054920a	062047	070122a	074323
659 10.5 Pt	659 13.3 Pt	669 6.1 Wd	663 9.1 Mn	651 8.9 Ah	650 9.8 Ah
668 10.5 Ch	668 13.4 L	675 5.8 Mc	667 9.2 Mn	655 7.7 Jo	651 9.8 Ah
678 11.3 Ma	Y TAU	675 5.6 Jo	668 9.2 L	655 8.0 Mn	655 10.0 Jo
T ORI	053920	676 5.6 Wa	677 9.4 L	656 8.0 Ah	656 10.4 Ah
053005a	649 7.1 Mn	677 6.0 Mc	R MON	658 7.7 Jo	659 9.6 Pt
649 10.2 L	663 7.1 Mn	677 6.3 Hu	063308	659 7.6 Pt	664 11.0 Ch
650 10.7 Jo	SU TAU	678 6.2 Mc	659 12.8 Pt	662 7.8 Mn	692 11.5 Bw
655 10.4 Jo	054319	678 5.7 Wa	NOV PIC	667 7.5 Ch	R CNC
656 10.1 L	649 9.6 L	683 6.4 Hu	*063462*	667 7.5 Wd	081112
657 10.2 L	656 9.7 Ch	687 6.9 Hu	645 8.4 En	668 6.9 Jo	651 11.0 Jo
658 10.1 Jo	659 9.6 Pt	V CAM	S LYN	669 7.3 Wd	655 10.9 Jo
661 10.5 Pt	661 9.7 Pt	054974	063558	687 7.1 Hu	664 11.0 Ch
661 9.9 Me	662 9.7 Pt	649 10.4 L	647 13.4 Ry	690 6.6 Hu	682 11.5 Pt
662 10.5 Pt	664 9.7 Ch	659 10.9 Pt	653 13.3 Ry	691 6.8 Me	687 10.7 Hu
667 10.6 Pt	667 9.6 Pt	677 11.0 L	658 13.4 Ry	Z GEM	V CNC
668 10.1 Jo	668 9.7 L	678 10.9 Pt	659 13.2 Pt	070122b	081617
668 10.1 L	677 9.7 L	681 11.1 Sf	668 13.2 L	659 12.5 Pt	649 8.7 Ah
668 10.5 Ch	678 9.6 Pt	690 11.1 Sf	X GEM	TW GEM	649 8.4 L
672 10.4 Bw	678 9.5 Ma	Z AUR	064030	*070122c*	656 8.9 Ah
675 10.8 L	682 9.6 Pt	055353	678 11.4 Ma	659 7.8 Pt	664 9.0 Ch
676 10.7 Jo	683 9.6 Pt	650 10.0 Jo	683 10.7 Bn	R CMI	677 9.2 L
677 10.1 Me	687 9.6 Pt	658 10.5 Jo	693 11.6 Bn	070310	682 9.4 Pt
677 10.5 L	S COL	659 10.8 Pt	Y MON	658 10.1 Jo	RT HYA
678 10.7 Pt	054331	661 10.8 Pt	065111	659 10.7 Pt	*082405*
678 9.9 Ma	638 12.0 Bl	662 10.6 Pt	649 13.6 L	675 10.8 L	678 9.0 L
678 9.9 Me	646 12.2 En	666 10.8 Pt	659 13.6 Pt	L_2 PUP	682 8.6 L
682 10.5 Pt	Z TAU	675 10.5 Mc	677 13.9 L	*071044*	R CHA
683 10.5 Pt	054615a	676 10.5 Jo	687 13.0 Hu	624 3.8 Sl	*082476*
687 10.5 Pt	675 12.0 L	677 10.4 Mc	690 12.9 Hu	637 4.0 Sl	619 8.7 Bl
691 10.0 Me	678 12.3 Ma	678 10.2 Me	X MON	RR MON	621 8.3 Sl
691 10.4 Bw	RU TAU	678 10.2 Pt	*065208*	071201	627 8.6 Bl
692 9.9 Me	054615c	682 10.3 Pt	658 8.5 L	675 13.8 L	638 8.5 Bl
AN ORI	675 12.6 L	683 10.2 Pt	R LYN	V GEM	U CNC
053005t	678 13.1 Ma	687 10.1 Pt	065355	071713	083019
678 11.4 Ma	R COL	688 10.4 Sf	648 8.7 Mn	649 11.2 L	649 11.1 L
691 11.4 Me	054629	690 9.9 Sf	648 8.7 Ah	659 11.2 Pt	677 13.1 L
S CAM	638 10.4 Bl	R OCT	649 8.8 Ah	677 9.8 L	S HYA
053068	646 10.9 En	*055686*	650 8.8 Ah	692 8.8 Bw	084803
650 8.0 Jo	α ORI	638 9.6 Bl	651 8.8 Ah	S CMI	664 11.5 Ch
653 8.1 Jo	054907	X AUR	656 8.9 Ah	072708	682 11.9 Pt
655 8.1 Jo	624 0.1 Sl	060450	657 8.9 Ah	651 8.9 Jo	T HYA
657 8.2 Jo	649 0.9 Si	656 11.8 L	661 9.1 Mn	655 9.4 Jo	*085008*
658 8.4 Jo	652 0.9 Si	659 12.1 Pt	668 9.1 L	658 10.5 Jo	664 7.4 Ch
659 8.6 Pt	653 1.0 Si	661 11.6 Ch	Z CMA	659 9.5 Pt	675 7.3 L
668 8.4 Jo	654 1.1 Si	667 11.3 Ch	*065911*	659 9.8 Ch	682 7.4 Pt
675 8.5 Jo	U ORI	677 10.4 L	624 9.3 Sl	U CMI	687 8.1 Hu
RR TAU	054920a	681 10.1 Sf	637 9.3 Sl	073508	T CNC
053326	624 8.1 Sl	690 9.7 Sf	V CMI	659 10.2 Pt	085120
649 11.8 L	648 6.3 Ah	V AUR	070109	668 9.9 L	651 8.1 Jo
656 11.2 L	649 6.2 Ah	061647	659 9.0 Pt	676 9.8 Jo	658 8.0 Jo
668 12.6 L	650 6.2 Ah	656 12.1 L	675 10.0 L	S GEM	664 9.0 Ch
677 11.0 L	650 5.8 Jo	677 12.0 L	692 10.8 Bw	073723	682 8.0 Pt
RU AUR	651 6.2 Ah	V MON	R GEM	655 12.3 Jo	V UMA
053337	656 6.1 Ah	*061702*	070122a	659 12.5 Pt	090151
661 10.6 Pt	656 5.8 Ch	659 11.2 Pt	648 9.3 Ah	T GEM	677 10.0 Mc
667 11.2 Pt	657 6.0 Ah	AG AUR	649 9.2 Ah	074323	678 10.1 Mc
668 9.9 Ch	659 5.8 Pt	062047	650 9.1 Ah	648 9.7 Ah	
	667 6.2 Wd	659 9.3 Mn	650 8.2 Jo	649 9.5 Ah	

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
W CNC	U HYA	T CVN	V CVN	U UMI	S CRB
090425	*103212*	122532	131546	141567	151731
677 12.8 L	664 5.3 Ch	666 11.8 Ch	661 6.9 GD	648 11.5 Ah	650 6.8 Ah
RX UMA	R UMA	682 11.0 Pt	R HYA	650 11.5 Ah	650 6.6 Jo
090567	103769	Y VIR	*132422*	652 10.8 Jo	652 6.8 Jo
675 10.9 L	648 10.8 Ah	*122803*	668 8.6 Ch	657 11.3 Jo	655 6.5 Ch
RW CAR	648 10.7 Mn	668 13.2 L	675 8.1 L	659 11.7 Pt	656 6.9 Jo
091868	650 11.2 Jo	U CEN	S VIR	S BOO	659 6.7 Pt
619[11.4 Bl	650 10.5 Ah	*122854*	*132706*	141954	661 7.0 Mn
R CAR	652 10.5 Sz	619[12.4 Bl	665 11.2 Ch	659 13.0 Pt	661 6.8 Th
092963	658 11.5 Jo	T UMA	RV CEN	675 13.2 L	667 7.0 Ah
619 6.2 Bl	668 11.2 Ch	123160	*133155*	RS VIR	RS LIB
624 6.5 Sl	678 12.1 Wd	648 7.3 Ah	619 7.9 Bl	142205	*151822*
627 6.2 Bl	682 12.0 Pt	649 7.4 Ah	619 8.4 En	668 9.7 L	619 10.5 Bl
637 6.8 Sl	V HYA	650 7.3 Ah	627 7.8 Bl	V BOO	627 10.0 Bl
638 7.0 Bl	*104620*	650 7.2 Jo	637 7.6 Bl	142539a	627 10.4 En
X HYA	666 7.2 Ch	651 7.3 Ah	T UMI	648 9.8 Ah	R NOR
093014	678 6.6 L	653 7.3 Jo	133273	649 10.1 Mn	*152849*
664 8.1 Ch	683 6.3 Pt	655 7.3 Jo	648 13.9 L	650 9.7 Ah	619 13.4 Bl
Y DRA	W LEO	656 7.2 Ah	677 13.4 L	650 9.2 Jo	627[12.8 En
093178	104814	657 7.2 Ah	T CEN	653 9.4 Jo	X LIB
675 13.1 L	668 11.9 Ch	658 7.3 Ah	*133633*	655 9.5 Jo	*153030*
R LMI	668 12.1 L	658 7.4 Jo	623 7.1 Bl	659 9.5 Pt	619 11.4 Bl
093934	RS CAR	658 7.6 Mn	623 7.0 Sl	661 10.2 Mn	627 11.0 Bl
651 11.0 Ah	*110361*	665 7.0 Ch	627 7.2 Bl	665 9.9 Ch	W LIB
656 10.9 Ah	624[12.3 Sl	667 7.5 Ah	627 7.1 Sl	R BOO	*153215*
664 11.2 Ch	S LEO	676 8.3 Wd	RT CEN	143227	623[12.5 Bl
682 11.8 Pt	110506	676 8.0 Jo	*134236*	648 7.3 Ah	S UMI
R LEO	668 11.4 L	682 8.8 Pt	623[13.0 Bl	650 7.5 Ah	153378
094211	668 11.1 Ch	R VIR	R CVN	659 7.5 Pt	645 10.5 Ch
651 9.5 Jo	683 11.3 Pt	123307	134440	665 7.5 Ch	648 9.9 Ah
651 10.1 Ah	RY CAR	683 7.2 Pt	666 10.5 Ch	S LUP	650 9.9 Ah
655 9.3 Jo	*111561*	RS UMA	682 10.3 Pt	*144646a*	653 9.6 Jo
656 9.6 Ah	619 12.4 Bl	123459	RX CEN	619[12.1 En	655 9.8 Jo
658 9.2 Jo	RS CEN	647 13.1 Ry	*134536*	621 13.5 Sl	657 10.0 Ah
682 9.0 Pt	*111661*	683 14.0 Pt	623 9.6 Bl	Y LUP	659 10.6 Pt
692 8.6 Me	619[12.7 Bl	S UMA	627 9.6 Bl	*145254*	678 11.4 Me
L CAR	W CEN	123961	T APS	619[13.7 Bl	678 11.7 Sf
094262	*115058*	648 11.0 Ah	*134677*	S APS	U LIB
624 3.5 Sl	619 11.3 Bl	650 11.1 Ah	619[13.2 Bl	*145971*	*153620a*
637 3.9 Sl	627 9.8 Bl	650 11.6 Jo	Z BOO	619 11.2 Bl	623 11.5 Bl
V LEO	637 9.1 Bl	653 11.7 Jo	140113	619 11.0 En	627 11.2 Bl
095421	R COM	655 12.0 Jo	668 13.0 L	621 11.1 Sl	T NOR
664[11.9 Ch	115919	658 12.0 Jo	Z VIR	623 11.2 Bl	*153654*
682 12.5 Pt	668[12.5 Ch	676 11.5 Jo	*140512*	627 11.3 Bl	619 7.2 En
S CAR	SU VIR	678 12.0 Wd	668[11.0 L	627 11.1 En	627 7.1 En
100661	120012	682 11.8 Pt	RU HYA	637 10.8 Bl	Z LIB
619 8.4 Bl	668 10.3 Ch	RU VIR	*140528*	646 10.9 En	*154020*
624 8.3 Sl	668 10.4 L	124204	623 10.1 Bl	Y LIB	623[12.7 Bl
627 8.8 Bl	683 9.5 Pt	668 13.5 L	627 10.3 Bl	*150605*	R CRB
637 8.3 Sl	T VIR	U VIR	R CEN	677 9.6 L	154428
638 8.6 Bl	*120005*	124606	*140959*	S SER	643 6.1 Ch
U UMA	668 10.0 L	668 13.4 L	619 10.0 Bl	151714	646 6.4 We
100860	683 9.8 Pt	U OCT	619 10.4 En	677 10.5 L	648 6.0 L
648 6.7 Mn	R CRV	*131283*	621 10.5 Sl	S CRB	648 6.1 Ah
658 6.7 Mn	*121118*	619 12.6 Bl	625 10.3 En	151731	649 6.1 Si
663 6.8 Mn	668 10.3 L	619 12.9 En	627 10.4 Bl	641 7.0 Th	649 5.8 Mn
Z CAR	SS VIR	627 11.8 Bl	637 10.5 Bl	648 6.8 Th	649 6.3 We
101058a	*122001*	637 11.0 Bl	641 9.4 Sl	648 6.6 Ah	650 6.0 Jo
619[11.8 Bl	668 7.6 L			649 7.0 Mn	650 6.2 Ah

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

R CrB
154428
655 6.0 Jo
657 6.2 We
657 6.2 Ch
658 6.0 Jo
659 6.1 Pt
661 6.1 Pt
661 5.7 Mn
666 6.0 Si
666 6.1 Pt
667 6.1 Ah
667 5.9 Si
669 6.1 Pt
671 6.2 Pt
672 6.1 Sh
675 6.0 L
676 6.0 L
677 6.0 L
677 6.0 Me
677 5.9 Cy
678 5.8 Cy
678 6.2 Pt
681 6.0 Cy
681 6.1 Sh
682 5.8 Cy
683 6.0 Cy
691 6.1 Me

X CrB
154536
659 12.4 Pt
677 13.4 L

V CrB
154639
648 8.1 Ah
650 8.3 Ah
656 8.4 Jo
658 8.4 Jo
659 7.8 Pt
661 8.4 Th

R Lup
154736
619[12.0 En
622 12.3 Sl

Z CrB
155229
676 11.5 L

RZ Sco
155823
619 9.0 En
627 9.1 En

Z Sco
160021
619 9.7 Bl
619 10.0 En
627 10.1 En
627 9.6 Bl
637 9.9 Bl

R Her
160118
650 8.8 Jo
652 8.6 Jo
655 8.7 Jo
657 8.6 Jo
658 8.6 Jo
659 8.7 Pt

U Ser
160210
659 10.4 Pt

X Sco
160221a
619[12.8 Bl

SX Her
160325
659 8.7 Pt
666 8.8 Pt
669 8.8 Pt
671 8.8 Pt
676 8.5 L
678 8.7 Pt

W Sco
160519
619[12.6 Bl

RU Her
160625
659 13.3 Pt

R Sco
161122a
619[12.8 Bl

S Sco
161122b
619[12.8 Bl

W CrB
161138
659 12.7 Pt

U Her
162119
643 11.5 Ch
650 11.5 Jo
652 11.2 Jo
653 11.2 Jo
655 11.3 Jo
657 11.0 Jo
658 11.0 Jo
659 11.5 Pt

SS Her
162807
659 10.7 Pt

T Oph
162815
619[12.0 Bl

S Oph
162816
619 11.2 Bl
627 11.9 Bl

W Her
163137
645 11.9 Ch

W Her
163137
652 10.7 Sz
659 11.8 Pt

R UMi
163172
650 10.5 Jo
653 10.4 Jo
657 10.1 Jo
658 10.0 Jo
668 10.3 Jo
672 10.2 Jo
676 10.3 Jo
675 10.1 L
678 9.4 Mc

R Dra
163266
648 10.3 Mn
650 11.0 Ah
650 10.6 Jo
653 10.7 Jo
655 11.0 Ch
657 10.8 Jo
658 11.7 Jo
659 11.5 Pt
671 11.0 Wd

RR Oph
164319
619[12.0 En
627[12.0 En

S Her
164715
659 12.5 Pt

RS Sco
164844
619 11.3 En
619 11.2 Bl
627 11.3 Bl
627 11.4 En
637 11.4 Bl
646 11.4 En

RR Sco
165030a
619 10.1 Bl
619 11.0 En
621 10.8 Sl
627 9.9 Sl
627 9.6 Bl
627 10.5 En
633 9.3 Sl
637 8.6 Bl
646 8.3 Sl
646 8.4 En

RV Her
165631
652 11.2 Ch
650 10.3 Jo
652 11.1 Rc
653 10.0 Jo
655 10.0 Jo

RV Her
165631
657 9.8 Jo
658 9.8 Jo
659 10.4 Pt
661 10.6 Rc
668 9.9 Jo
672 10.2 Jo
676 9.9 L
679 10.3 Rc
685 10.4 Rc

RT Sco
165636
619 14.2 Bl
623 13.4 Bl
627 12.8 Bl
637 11.6 Bl

RT Her
170627
643 11.0 Ch
648 10.8 Th
650 10.5 Jo
653 10.7 Jo
655 10.9 Jo
657 11.4 Jo
659 11.7 Pt

RW Sco
170833
619 10.9 En
619 10.8 Bl
627 10.5 En
627 10.3 Bl
637 9.8 Bl

Z Oph
171401
648 9.3 Ah
659 9.6 Pt

RS Her
171723
650 10.9 Jo
653 10.7 Jo
655 10.3 Jo
657 9.6 Jo
659 10.9 Pt
668 8.6 Jo
672 8.3 Jo

S Oct
172486
619 12.5 Bl
622 12.8 Sl
633 12.9 Sl

RU Oph
172809
659 10.6 Pt
676 9.1 L

RU Sco
173543
619 14.2 Bl
623 13.4 Bl
627 12.8 Bl
637 11.6 Bl

RT Her
170627
643 11.0 Ch
648 10.8 Th
650 10.5 Jo
653 10.7 Jo
655 10.9 Jo
657 11.4 Jo
659 11.7 Pt

RW Sco
170833
619 10.9 En
619 10.8 Bl
627 10.5 En
627 10.3 Bl
637 9.8 Bl

Z Oph
171401
648 9.3 Ah
659 9.6 Pt

RS Her
171723
650 10.9 Jo
653 10.7 Jo
655 10.3 Jo
657 9.6 Jo
659 10.9 Pt
668 8.6 Jo
672 8.3 Jo

S Oct
172486
619 12.5 Bl
622 12.8 Sl
633 12.9 Sl

RU Oph
172809
659 10.6 Pt
676 9.1 L

RU Sco
173543
619 9.6 En
620 8.7 Bl
627 8.8 Bl

RU Sco
173543
627 9.6 En
637 8.8 Bl

SV Sco
174135
620[12.2 Bl

W Pav
174162
622 13.5 Sl

RS Oph
174406
622 13.7 Sl
627 13.5 Sl
646 12.5 Sl
659 12.4 Pt

U Ara
174551
619 12.0 En
627 12.3 En

T Dra
175458a
659 12.9 B

UY Dra
175458b
660 11.4 B

RY Her
175519
643 10.4 Ch
656 11.0 Jo
657 11.0 Ch
659 11.4 Pt
676 12.4 L

V Dra
175654
659 10.4 Pt
675 11.3 L
675 12.0 Md

R Pav
180363
619 7.8 En
627 8.2 En

T Her
180531
648 9.8 Ah
650 9.4 Ah
650 9.4 Jo
653 8.8 Jo
655 8.7 Jo
657 9.1 Ah
657 9.0 Ch
659 9.3 Pt
667 8.5 Ah
676 7.9 Jo
676 8.3 L
678 8.1 Me

W Dra
180565
659 9.9 Pt
660 10.0 B
675 10.7 L
675 10.6 Md
687 11.9 Md

T Dra
657 12.3 Jo
659 12.9 B
659 12.6 Pt
676 13.0 L

RV Sgr
182133
620[13.6 Bl

SV Her
182224
676 14.4 L

T Ser
182306
658[12.1 Fe

SV Dra
183149
676 14.1 L
677 13.2 Hu

RZ Her
183225
678 12.8 L

X Oph
183308
649 8.8 Si
649 8.7 Mn
650 8.4 Jo
653 8.5 Jo
654 8.6 Ch
657 8.5 Jo
658 8.5 Jo
659 8.5 Pt
661 8.4 Mn
667 8.7 Si
668 8.6 Jo
676 8.6 Jo
676 8.4 Mn
676 8.6 L

RY Lyr
184134
654[12.2 Ch
678 14.1 L

R Sct
184205
621 6.0 Sl

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R SCT	R LYR	R AQL	R SGR	AF CYG	T PAV
184205	185243	190108	*191019*	192745	*193972*
628 6.3 Sl	649 4.3 Si	672 6.5 Jo	627 10.3 En	650 6.6 Ah	623 13.7 Bl
633 6.6 Sl	661 4.3 Si	676 7.3 Mn	651 9.0 Mu	651 6.5 Ah	RT CYG
645 5.9 Ch	S CRA	V LYR	654 9.4 Ch	656 6.5 Ah	194048
646 6.0 Sl	*185437a*	190529a	659 9.3 Pt	667 6.4 Ah	644 10.8 Ch
650 5.5 Jo	615 11.6 En	657[13.3 Ch	678 8.5 L	TY CYG	650 11.7 Jo
652 6.0 Rc	620 11.6 Bl	677 12.9 Hu	RY SGR	192928	651 10.7 GC
653 5.5 Jo	621 11.9 Sl	RX SGR	*191033*	657[13.8 Ch	652 11.0 GC
655 5.6 Ch	624 12.1 Sl	*190818*	619 11.0 En	678 14.0 L	653 11.5 Jo
656 5.5 Bc	627 12.0 En	615[12.4 En	620 11.1 Bl	RT AQL	655 10.7 Jo
657 5.6 Jo	628 12.3 Sl	658[11.8 Fe	621 11.4 Sl	193311	657 10.0 Jo
658 5.6 Jo	633 12.0 Sl	RW SGR	623 10.9 Bl	651 11.8 GC	658 9.7 Jo
659 5.5 Pt	647 12.1 Sl	*190819a*	625 11.0 En	652 11.8 GC	659 10.6 Pt
661 5.3 Pt	ST SGR	615 9.6 En	627 11.0 Bl	656 12.0 B	668 8.9 Ch
661 5.7 Mn	*195512a*	627 9.2 En	637 10.6 Bl	657 11.3 Ch	668 8.9 Jo
661 5.5 Rc	657 9.2 Ch	651 9.2 GC	643 11.0 En	659 12.4 Pt	669 9.0 Wd
662 6.3 Hu	658 9.2 Fe	654 8.8 Ch	647 10.6 Sl	678 12.7 L	671 8.9 Wd
666 5.2 Pt	676 10.2 L	658 9.0 Fe	648 10.8 L	SV AQL	672 8.5 Jo
666 5.3 Rc	R CRA	659 8.6 Pt	655 11.0 Ch	193411	676 8.2 Jo
668 5.5 Jo	*185537a*	678 9.8 L	666 9.6 Pt	651 13.3 GC	676 8.4 B
669 5.2 Cy	615 12.6 En	BH SGR	TY SGR	652 13.3 GC	676 8.6 Wd
669 5.2 Pt	621 13.2 Sl	*190819b*	*191124*	R CYG	677 8.5 Hu
670 5.3 Jo	624 13.3 Sl	651 13.2 GC	620[12.4 Bl	193449	678 8.3 Mc
671 5.4 Cy	627 12.6 En	TY AQL	S SGR	648 8.0 Ah	681 8.2 Wd
671 5.7 Wd	628 13.3 Sl	*190907*	*191319a*	649 8.1 Ah	690 7.2 Hu
671 5.2 Pt	647 12.3 Sl	659 10.2 Pt	619 11.6 En	649 7.2 Si	TU CYG
675 5.9 Mc	T CRA	S LYR	620 11.3 Bl	649 7.6 We	647[13.2 Ry
676 5.1 Jo	*185537b*	190925	627 11.2 Bl	650 7.5 Jo	651[13.3 GC
676 5.3 Cy	620 13.0 Bl	654[12.0 Ch	627 11.3 En	650 7.8 Ah	659 14.1 Pt
676 5.8 Mn	621 13.0 Sl	678[14.4 L	637 11.3 Bl	651 8.0 Ah	677[12.3 Hu
676 5.2 L	624 12.9 Sl	X LYR	651 10.8 Mu	653 7.5 Jo	678[14.1 L
677 5.1 Hu	628 12.8 Sl	190926	654 11.2 Ch	654 8.4 Ch	X AQL
678 5.4 Pt	647 12.7 Sl	659 9.0 Pt	659 10.6 Pt	655 7.7 Jo	194604
678 5.5 Mc	Z LYR	RS LYR	676 11.1 L	656 8.0 Ah	648 10.0 Th
678 5.5 Cy	185634	190933a	Z SGR	657 7.7 Jo	650 10.2 Jo
679 5.2 Rc	654[12.3 Ch	654 11.6 Ch	*191321*	658 7.8 Jo	658 10.8 Ch
681 5.4 Cy	RT LYR	657 11.6 Ch	619 9.5 En	659 8.2 Pt	659 10.7 Pt
683 5.1 Cy	185737	659 12.3 Pt	627 9.3 En	660 8.1 B	659 10.7 B
683 5.6 Pt	652[14.0 GC	676 11.3 L	678 11.3 L	661 7.6 Si	678 12.3 L
685 5.3 Rc	654[12.5 Ch	RU LYR	SW SGR	667 8.0 Ah	χ CYG
687 5.6 Pt	676 13.6 L	190941	*191331*	668 8.0 Jo	194632
688 5.7 Pt	V AQL	659 14.6 Pt	620 12.9 Bl	669 8.4 Wd	629 6.1 Jo
Nov AQL	*185905*	677[12.5 Hu	TZ CYG	670 7.4 Si	633 5.5 Pt
184300	649 7.8 Mn	U DRA	191350	671 8.5 Wd	634 5.5 Jo
650 10.6 Jo	661 7.8 Mn	190967	659 10.9 Pt	672 7.9 Jo	635 5.5 Lv
653 10.7 Jo	676 7.9 Mn	655 12.1 Ch	U LYR	676 8.7 Wd	636 5.6 Lv
655 10.7 Jo	R AQL	659 11.7 Pt	191637	676 8.0 Jo	637 5.5 Lv
655 10.8 Ch	190108	676 12.6 L	650 8.7 Jo	677 8.9 Mc	645 6.6 Ch
657 11.0 Jo	648 6.1 Ah	677 12.3 Hu	653 8.7 Jo	678 9.0 Mc	646 6.1 We
658 11.0 Jo	648 6.5 Ch	W AQL	655 8.7 Jo	681 8.8 Wd	649 6.8 Si
659 11.6 Pt	649 6.0 We	*191007*	657 8.7 Jo	RV AQL	650 6.4 Lv
666 11.5 Pt	649 6.0 Mn	654[12.6 Ch	659 8.6 Pt	193509	650 6.3 Ah
678 11.5 Pt	650 6.3 Ah	T SGR	668 8.9 Jo	659 10.0 Pt	650 5.9 Jo
687 11.6 Pt	657 6.5 Ah	*191017*	672 8.7 Jo	661 9.6 Ch	651 6.5 Lv
RX LYR	657 6.6 Ch	654 11.0 Ch	676 8.8 Jo	677 9.6 Hu	652 6.6 Si
185032	659 6.1 Pt	659 10.7 Pt	AF CYG	678 9.7 L	652 6.5 Lv
654[12.5 Ch	661 6.3 Mn	R SGR	192745	T PAV	653 6.6 Si
677[13.0 Hu	667 6.9 B	*191019*	648 6.6 Ah	*193972*	653 6.0 Jo
690[12.5 Hu	667 7.0 Ah	619 10.9 En	649 6.6 Ah	622 13.9 Sl	656 6.3 We

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
χ CYG	NOV CYG	R TEL	R DEL	U CYG	V CYG
194632	195553	*200747*	201008	201647	203847
656 6.2 Lv	658[13.1 Ch	624 12.5 Bl	650 9.0 Ah	673 7.8 GD	663 9.8 Mn
656 7.1 Ch	678[12.2 Pt	629 12.6 En	657 9.0 Ah	673 8.1 Md	665 9.0 B
657 6.1 Jo	RR TEL	RU AQL	659 8.8 Th	674 8.5 Mn	667 9.7 Mn
657 6.8 Ah	*195656*	200812	659 9.0 Pt	676 7.7 Jo	671 10.2 Hu
658 6.3 Jo	627 12.6 En	649 14.0 L	660 9.0 B	676 8.4 Wd	674 9.8 Mn
659 6.5 Pt	Z CYG	658[13.0 Ch	678 9.3 Sf	678 9.2 Sf	677 9.9 Hu
659 6.4 Lv	195849	W CAP	678 9.1 L	678 8.8 Mc	678 8.8 L
661 7.4 Si	644 9.2 Ch	*200822*	680 9.5 Mg	681 8.3 Wd	678 10.0 Sf
666 7.5 Si	654 9.4 Ch	624 12.5 Bl	683 9.5 Sf	681 8.2 Md	690 9.9 Hu
667 7.2 Bg	659 9.3 Pt	Z AQL	RT CAP	683 7.8 B	Y AQR
667 7.3 Sh	676 10.8 B	*200906*	*201121*	U MIC	*203905*
667 7.3 Ah	678 11.5 L	659 9.3 B	659 6.3 Pt	*202240*	650 9.7 Jo
667 7.5 Si	S TEL	659 9.5 Pt	SX CYG	627[13.0 Bl	652 9.5 Jo
668 8.0 Lv	*195855*	661 9.5 Ch	201130	RU CAP	654 10.1 GC
668 7.0 Jo	624 12.8 Sl	676 10.3 Bg	657[13.1 Ch	*202622*	655 9.4 Jo
669 7.3 Wd	624 13.1 Bl	R SGE	663[11.4 Cy	629[12.0 En	656 9.8 GC
669 7.2 Bg	SY AQL	200916	676[12.7 Cy	Z DEL	656 9.4 Jo
670 7.7 Si	200212	650 10.8 Jo	RT SGR	202817	658 9.3 Jo
670 8.0 Lv	656 9.5 Ch	655 10.4 Jo	*201139*	661[12.9 Ch	659 9.8 Pt
670 7.2 B	659 9.0 Pt	676 10.6 Jo	624 12.4 Bl	677 12.7 Hu	661 9.5 Ch
671 7.2 Wd	659 9.5 B	RS CYG	629 12.4 En	ST CYG	668 9.3 Jo
671 7.2 Sh	678 9.6 L	200938	WX CYG	202954	679 9.8 B
672 7.7 Lv	S CYG	636 7.8 Ch	201437b	651 13.4 GC	683 9.8 Bl
673 7.3 Jo	200357	645 7.6 Ch	650 11.9 Jo	652 13.8 GC	T DEL
676 7.5 Jo	657 9.5 Ch	649 8.5 Si	653 11.9 Jo	659 13.6 Pt	204016
676 7.9 Wd	659 9.9 Pt	650 7.4 Jo	655 12.3 Jo	659 13.5 B	657 11.6 Ch
676 7.5 Bg	659 11.4 B	653 7.4 Jo	658 12.5 Jo	678 14.2 L	659 13.0 Pt
676 7.4 Wd	659 11.3 Pt	654 7.8 Ch	659 11.7 Pt	V VUL	665 12.1 B
678 8.2 Lv	661 11.1 Ch	655 7.3 Jo	659 12.0 Cy	203226	678 10.3 Cy
680 8.1 Mg	676 11.5 L	657 7.4 Ch	668[12.5 Jo	659 8.7 Pt	678 10.2 L
681 8.0 Wd	676 9.6 B	658 7.3 Jo	673 12.2 Md	R MIC	683 9.8 B
681 7.7 Bg	676 8.9 Jo	658 8.0 GD	676 12.0 B	*203429*	V AQR
682 7.8 Me	677 10.2 Hu	659 7.8 Cy	676 12.4 Cy	624 13.5 Bl	204102
688 8.0 Bg	690 10.7 Hu	659 7.2 Pt	681 12.5 Cy	629 12.2 En	659 8.0 Pt
S PAV	S AQL	661 7.7 Si	683 12.5 Cy	Y DEL	674 8.8 Md
194659	200715a	663 7.4 Cy	V SGE	203611	678 8.5 L
622 6.9 Sl	650 11.7 Jo	664 7.8 Ch	201520	653 13.8 B	679 8.7 B
627 7.9 En	655 11.5 Jo	667 7.6 Si	658 7.9 Ch	659 13.7 B	W AQR
RR SGR	658 11.6 Ch	668 7.3 Jo	U CYG	678 13.5 L	*204101*
194929	659 9.4 B	669 7.6 Cy	201647	S DEL	656[13.4 GC
623[13.2 Bl	659 11.5 Pt	669 8.0 Wd	648 8.8 Mn	203816	676 13.3 L
627[13.2 En	667 10.1 Bg	669 7.8 Ch	650 9.4 Mu	652 9.5 Sz	683[12.4 Cy
RU SGR	669 9.8 Bg	670 7.6 Si	650 7.8 Jo	659 10.0 Pt	U CAP
195142	676 9.5 Bg	671 7.8 Wd	651 9.3 Mu	660 9.8 B	*204215*
624 11.0 Bl	676 9.4 Jo	671 7.8 Sh	653 7.8 Jo	661 9.2 Ch	624[13.5 Bl
627 11.2 Bl	677 10.0 Me	673 7.2 Jo	655 7.7 Jo	662 9.8 Hu	V DEL
627 12.1 En	681 9.5 Bg	676 8.1 Wd	655 8.7 Mn	671 10.3 Hu	204318
637 12.0 Bl	RW AQL	676 7.2 Jo	656 7.8 B	674 10.0 Md	653[13.8 B
RR AQL	200715b	676 7.8 Cy	658 7.7 Jo	680 10.2 Mg	659[13.7 B
195202	650 9.4 Jo	678 8.0 GD	658 8.2 GD	682 10.2 Hu	661 13.3 Ch
649 13.8 L	655 9.2 Jo	678 7.5 L	659 7.7 Pt	690 10.1 Hu	680[13.1 Mg
659 13.2 B	659 9.2 Pt	678 7.5 Me	663 8.6 Mn	V CYG	T AQR
RS AQL	667 9.3 Bg	681 7.6 Cy	668 7.8 Jo	203847	*204405*
195308	669 9.2 Bg	R DEL	669 7.9 Wd	648 10.5 Mn	645 9.2 Ch
658 13.0 Ch	675 9.1 Bg	201008	669 9.2 Mu	655 10.1 Mn	649 9.1 Mn
658 12.5 B	676 9.8 Jo	648 9.2 Th	671 7.7 Jo	658 9.7 Ch	650 8.6 Jo
676 12.9 L		648 8.9 Ah	671 8.1 Wd	659 8.9 Pt	652 8.7 Jo

Variable Star Observations Received During December, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T Aqr	TW Cyg	RR Aqr	RU Cyg	RZ Peg	S Aqr
204405	210129	*210903*	213753	220133b	*225120*
655 8.9 Jo	654[13.0 GC	649 13.0 L	663 8.8 Ry	659 11.9 Pt	679 8.8 B
657 9.0 Jo	657[13.5 Ch	656 13.5 B	677 8.1 Me	678 12.5 Hu	RW Peg
658 9.5 Jo	660[13.8 B	659 12.5 Pt	692 7.2 Bw	682 12.4 Hu	225914
659 11.1 B	X Cap	664 12.3 Ch	RV Cyg	Y Peg	649 12.9 L
659 9.6 Pt	*210221*	678 14.4 L	213937	220613	652 12.5 Sz
661 9.9 Ch	624[12.7 Bl	X Peg	635 7.6 Lv	654 11.1 GC	659 13.2 Pt
661 10.1 Mn	X Cep	211614	636 7.2 Lv	659 12.6 Pt	662 12.1 Ch
668 10.4 Jo	210382	649 13.6 L	650 7.0 Lv	675 9.8 Md	679 10.6 B
676 10.8 Mn	654 11.7 Ch	659 13.6 Pt	651 7.0 Lv	679 9.9 B	691 9.7 Ma
678 11.0 Me	RS Aqr	677[13.4 Hu	656 7.2 Lv	680 10.1 Mg	R Peg
RZ Cyg	*210504*	690[12.4 Hu	659 6.7 Lv	RS Peg	230110
204846	654 13.3 GC	T Cap	659 6.6 Pt	220714	648 10.5 Ah
659 13.6 B	656 13.2 B	*211615*	668 7.0 Lv	654 11.0 GC	650 10.4 Ah
659 13.3 Pt	678 12.3 L	624 9.6 Bl	670 6.5 Lv	659 11.2 Pt	659 10.2 Pt
677 12.8 Hu	Z Cap	627 9.9 Bl	672 6.6 Lv	675 11.7 Md	662 10.3 Ch
S Ind	*210516*	638 10.0 Bl	677 6.6 Lv	679 11.6 B	678 10.5 Sf
204954	654[13.4 GC	659 11.5 B	678 6.6 Lv	680 12.1 Mg	688 10.2 Bg
622 8.9 Sl	659 13.2 Pt	664 11.5 Ch	RR Peg	R PsA	690 10.6 Sf
627 9.4 Bl	676 13.2 L	676 12.2 L	214024	*221230*	V Cas
629 9.6 En	R Equ	S Mic	654[13.0 GC	630[12.0 En	230759
637 9.9 Bl	210812	*212030*	658[13.0 Ch	X Aqr	659 10.4 Cy
X Del	659 14.3 Pt	627 12.8 En	659 13.6 B	*221321*	659 10.6 Pt
205017	T Cep	628 11.5 Bl	662[13.0 GC	630[12.4 En	667 9.7 B
656 11.0 B	210868	638 11.8 Bl	680 13.5 Mg	T Gru	676 9.3 Cy
659 10.5 Pt	645 7.8 Ch	Y Cap	R Gru	*221938*	678 8.8 Me
661 10.8 Ch	648 8.0 Th	*212814*	*214247*	630 9.2 En	679 9.0 Sf
675 12.4 Md	648 8.4 Mn	624 12.0 Bl	627 12.0 En	645 9.2 En	690 8.6 Sf
677 12.5 Hu	648 8.3 Ah	628 11.7 Bl	628 12.0 Bl	S Gru	W Peg
678 12.1 L	649 8.0 Ah	638 12.0 Bl	629 11.6 En	*221948*	231425
682 12.5 Hu	650 7.9 Th	659 12.7 B	638 11.4 Bl	625 10.0 En	679 11.6 Hu
683 12.6 B	650 7.4 Jo	664 10.7 Ch	643 11.0 En	630 10.3 En	681 12.4 Bw
690 12.9 Hu	650 8.1 Ah	676 13.2 L	V Peg	645 11.1 En	690 12.0 Hu
RR Cap	651 8.1 Ah	W Cyg	215605	RV Peg	690 12.1 Mg
205627	655 7.2 Jo	213244	654 8.5 GC	*222129*	692 12.1 Bw
629 8.5 En	656 7.7 Ah	668 6.5 L	658 8.4 Ch	658[13.3 Ch	S Peg
T Oct	657 8.0 Ah	677 6.5 L	659 8.2 Pt	679[13.7 B	231508
205782	658 7.1 Jo	S Cep	670 8.6 B	690[12.8 Hu	648 11.0 Th
621 9.4 Sl	659 7.7 Pt	213678	674 8.9 Md	S Lac	656 11.3 Jo
633 10.0 Sl	659 8.2 Mn	648 9.6 Th	U PsA	*222439*	659 11.7 Pt
R Vul	661 7.8 Th	651 9.4 GC	*215628*	659 11.9 Pt	690 9.4 Mg
205923a	663 8.0 Mn	652 9.6 GC	630[12.2 En	680 13.0 Mg	RY Cep
648 10.8 Ah	664 6.9 Ch	653 9.5 B	U Aqr	R Ind	231878
650 11.6 Jo	667 6.9 Sh	654 9.6 Ch	*215717*	*222867*	655 11.0 Ch
650 11.0 Ah	669 7.0 Wd	659 8.8 Pt	659 12.2 Pt	624 10.5 Bl	V Phe
655 12.0 Jo	669 6.9 Sh	661 9.6 Th	664 11.7 Ch	628 10.5 Bl	*232746*
656 11.3 B	671 6.9 Wd	673 9.6 Md	676 12.1 L	630 9.9 En	645 10.4 En
658[12.5 Jo	671 6.7 Sh	678 9.6 Hu	S PsA	638 9.7 Bl	Z And
658 12.0 Ch	673 6.8 Jo	682 9.7 Hu	*215828*	645 9.5 En	659 10.7 Pt
659 11.6 Pt	676 6.7 Jo	687 10.2 Md	630 9.9 En	T Tuc	663 10.6 Hu
683 12.3 B	676 7.0 Wd	RU Cyg	RT Peg	*223462*	671 10.5 Hu
V Cap	676 6.8 Sh	213753	215934	627 9.3 En	673 10.7 Hu
210124	681 7.1 Wd	647 9.4 Ry	648 10.3 Th	645 8.3 En	677 10.8 Hu
624 9.7 Bl	681 6.9 Sh	648 9.3 Ah	674 10.9 Md	R Lac	678 10.6 Cy
627 10.2 Bl	682 6.9 Me	650 9.2 Ah	RY Peg	*223841*	681 11.1 Md
630 10.4 En	690 6.5 Hu	653 9.1 Ry	220133a	659 14.6 Pt	681 10.9 Bw
638 10.9 Bl		656 9.0 Ah	678 12.0 Hu	663[12.4 Hu	683 10.6 Hu
676 12.3 L		658 8.9 Ry	682 12.0 Hu	679 13.4 Hu	690 10.7 Hu
		659 8.7 Pt		690[12.5 Hu	692 10.9 Bw

VARIABLE STAR OBSERVATIONS RECEIVED DURING DECEMBER, 1931.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
ST AND			**R AQR**			**R AQR**			**RR CAS**			**R TUC**			**W CET**		
233335			*233815*			*233815*			235053			*235265*			*235715*		
650	11.0	Th	624	8.4	Bl	659	9.0	Pt	655	11.9	B	624	13.2	Sl	648	9.8	Th
657	10.0	Jo	628	8.5	Bl	660	9.0	Mn	683	11.6	Bn	647	13.7	Sl	649	9.6	Mn
659	10.8	Pt	638	8.4	Bl	676	8.8	Jo	693	11.3	Bn	**R CAS**			660	10.1	Mn
665	10.6	Bo	645	8.8	Ch	677	8.5	Me	**R PHE**			235350			**SV AND**		
677	10.5	Bo	649	9.0	Mn	**Z CAS**			*235150*			649	10.4	Mn	235939		
678	10.4	Bo	649	9.0	L	233956			624	10.1	Sl	659	10.5	Mn	659	12.6	Pt
681	10.5	Bo	650	8.7	Jo	678[	13.1	Cy	645[	11.3	En	**Z PEG**			681	11.6	Bw
683	10.8	Cy	653	8.7	Jo	680[	14.2	Mg	**V CET**			235525			691	11.4	Bw
690	10.2	Mg	658	8.7	Jo	691[	13.1	Bw	*235209*			659	12.5	Pt			
									624	12.8	Bl						
									690	13.8	Mg						

RAPIDLY VARYING IRREGULAR VARIABLES.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
005840 RX ANDROMEDAE—							081473 Z CAMELOPARDALIS—						
	6647.3	12.0	Ry	6662.7	12.0	Pt		6677.7	12.0	Hu	6683.6	12.1	Pt
	6648.3	11.7	Ry	6663.5	11.1	Ry		6678.5	11.5	Me	6683.7	12.5	Hu
	6649.5	10.9	Ry	6672.6	13.6	Br		6678.7	11.1	Pt	6687.6	12.6	Pt
	6653.3	12.2	Ry	6673.6	14.1	Br		6679.5	11.6	Me	6687.8	12.9	Hu
	6654.3	12.9	Ry	6674.6	13.5	Br		6679.7	11.5	Hu	6690.7	13.1	Hu
	6656.6[	12.5	Ry	6678.7	11.3	Pt		6682.8	11.7	Pt			
	6657.2	12.9	Ry	6682.8	13.2	Pt	094512 X LEONIS—						
	6658.5	13.3	Ry	6683.6	13.2	Pt		6682.8	12.5	Pt			
	6659.6	13.1	Pt	6687.6	12.2	Pt	202946 SZ CYGNI—						
	6661.7	13.1	Pt					6659.6	8.9	Pt	6671.5	8.9	Pt
060547 SS AURIGAE—								6661.7	9.3	Pt	6678.5	9.4	Pt
	6656.4[	13.9	L	6678.6	11.1	Me		6662.7	9.3	Pt	6682.8	9.5	Pt
	6657.2[	13.0	Ch	6678.6	10.8	Cy		6666.6	9.5	Pt	6683.6	9.1	Pt
	6659.6[	12.6	Pt	6678.7	11.0	Pt		6669.8	9.2	Pt	6687.6	8.8	Pt
	6661.3[	13.9	L	6679.7	11.0	Fe	213843 SS CYGNI—						
	6662.2[	13.0	Ch	6680.7	10.8	O		6636.2	12.0	Ch	6656.6	11.9	Bf
	6667.8[	12.5	Pt	6680.7	10.7	Sa		6648.2	11.3	L	6657.3	11.9	Ah
	6668.3[	12.5	L	6681.6	10.9	Cy		6648.3	11.8	Ah	6657.6	11.6	B
	6669.7	12.4	Cy	6682.8	11.0	Pt		6648.6	11.8	Jo	6657.7	11.8	Jo
	6675.7[	13.0	L	6683.6	11.1	Pt		6649.3	11.7	L	6658.2	11.3	Ch
	6677.6	10.8	Me	6683.6	10.9	Cy		6649.5	11.8	Ah	6658.7	11.7	Jo
	6677.7	10.8	L	6687.6[	12.6	Pt		6650.4	11.9	Ah	6659.5	11.5	Lv
	6678.3	10.8	L	6692.7	13.9	Bw		6650.6	11.8	Bc	6659.6	11.3	Cy
074922 U GEMINORUM—								6650.6	12.0	Lv	6659.6	11.4	Pt
	6624.3[	13.3	Sl	6668.5[	12.3	Ch		6650.6	11.7	Jo	6661.7	11.6	Pt
	6637.3	9.0	Sl	6668.7	13.8	L		6651.5	12.0	Lv	6661.7	11.4	Me
	6638.3	9.0	Sl	6677.6[	13.3	L		6651.5	11.8	Ah	6662.7	11.6	Pt
	6649.7	12.1	L	6678.7[	12.4	Pt		6651.5	11.5	GC	6663.6	11.6	Cy
	6656.7	14.0	L	6678.7[	13.3	Cy		6651.6	11.7	Jo	6664.6	11.1	Cy
	6659.7[	12.4	Cy	6680.7[	11.2	Sa		6652.5	12.0	Lv	6666.6	10.5	B
	6661.7[	13.3	Pt	6682.8[	12.4	Pt		6652.5	11.7	GC	6666.6	9.6	Pt
	6667.8[	11.8	Pt	6687.6[	12.4	Pt		6652.6	11.8	Jo	6667.6	10.0	B
081473 Z CAMELOPARDALIS—								6653.6	12.0	Jo	6668.1	9.0	Ch
	6648.2	13.0	L	6664.3	11.5	Ch		6653.6	11.5	B	6668.3	9.7	L
	6649.3	13.0	L	6666.6	11.1	Pt		6654.2	11.8	Ch	6668.6	9.5	Lv
	6656.7	11.2	L	6668.3	11.5	L		6655.6	11.5	B	6668.6	9.3	Jo
	6659.6	11.1	Pt	6669.8	11.0	Pt		6655.7	12.0	Jo	6669.5	8.9	Cy
	6661.7	11.9	Pt	6671.7[	11.5	Hu		6656.5	12.0	Ah	6669.5	9.4	Wa
	6662.7	12.0	Pt	6675.7	11.9	L		6656.6	11.5	Lv	6669.6	9.0	Jo
	6662.7	11.8	Pt	6677.3	12.1	L		6656.6	11.3	Cy	6669.6	8.9	Wd
	6663.7	11.6	Hu	6677.6	11.6	Me		6656.6	11.8	Jo	6669.6	9.2	Ae
	6663.8	11.7	Hu	6677.7	11.7	L		6656.6	11.8	Bc	6669.8	9.2	Pt

213843 SS Cygni—				213843 SS Cygni—			
6670.5	9.1 Wa	6674.6	9.2 Br	6678.5	10.2 Me	6682.5	11.3 Me
6670.6	9.0 Ae	6674.7	9.3 Md	6678.5	10.4 Sf	6682.7	11.9 Hu
6670.6	8.5 Lv	6675.6	9.6 Jo	6678.5	10.4 Pt	6682.8	11.6 Pt
6670.6	9.0 B	6676.5	9.8 B	6678.6	10.6 Cy	6683.5	11.5 Cy
6670.6	8.7 Jo	6676.5	9.5 Cy	6678.6	11.0 Wa	6683.5	11.8 Sf
6670.7	8.8 Cy	6676.5	9.7 Wa	6678.7	11.0 GD	6683.6	11.7 Ae
6671.5	8.7 Cy	6676.5	9.8 Wd	6678.6	10.9 Ma	6683.6	11.7 Pt
6671.5	8.9 Pt	6676.5	9.9 Bg	6679.5	10.6 Me	6683.6	11.6 B
6671.6	8.7 Jo	6676.6	9.8 Jo	6679.6	11.1 Sf	6683.7	11.7 Hu
6671.6	8.7 Wd	6676.6	9.7 Ae	6679.6	11.9 B	6687.7	11.9 Md
6671.6	8.6 Ma	6676.7	9.9 We	6680.5	11.5 Ae	6687.6	11.4 Pt
6671.7	8.9 Hu	6677.3	10.4 L	6680.5	11.5 Mg	6688.6	11.7 Bg
6672.4	8.6 Lv	6677.5	10.1 Lv	6681.5	11.8 Sf	6690.5	11.8 Sf
6672.6	9.0 Jo	6677.6	10.2 Ae	6681.5	11.6 Wd	6690.6	12.0 Mg
6672.6	8.8 Br	6677.7	10.3 Hu	6681.6	11.7 Md	6690.7	11.9 Hu
6673.6	9.1 B	6677.8	10.0 Me	6681.6	11.3 Cy	6691.6	11.9 Ma
6673.6	9.0 Br	6678.3	10.5 L	6681.6	11.7 Bg	6691.7	11.5 Me
6673.7	9.0 Md	6678.5	10.1 Lv	6681.7	11.7 Ae		

Summary of Observations for December, 1931.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	38	129	MacQueen	Mu	3	5
Allen, L. B.	Ae	1	6	Marsh	Ma	21	23
Allen, P. R.	Al	2	2	McLeod	Mc	13	21
Baldwin	Bl	89	150	Meek	Me	26	43
Bigelow	Bw	15	24	Mennella	Mn	25	59
Boutell	Bo	9	34	Millard	Md	17	23
Bouton	B	66	88	Monnig	Mg	12	12
Brocchi	Br	13	18	Olcott	O	4	4
Brown, A. N.	Bn	3	5	Peltier	Pt	204	280
Buckstaff, E.	Bf	1	1	Popkavich	Pk	2	2
Buckstaff, R.N.	Bc	2	3	Recinsky	Rc	2	9
Bunting	Bg	10	22	deRoy	Ry	7	23
Campbell	C	2	2	Shinkfield	Sl	40	90
Chandra	Ch	137	160	Shultz	Sz	5	5
Cilley	Cy	17	53	Simpson	Si	9	27
Ensor	En	75	106	Smith, F. W.	Sf	18	36
Ferris	Fe	5	5	Smith, L.	Sh	4	10
Georgetown	GC	20	28	Stark	Sa	3	4
Godfrey Club	GD	3	5	Thiele	Th	14	23
Houston	Hu	42	110	Watson	Wa	3	8
Jones	Jo	85	365	Webb	Wd	16	39
Lacchini	L	129	174	Wetherbee	We	4	7
Levy	Lv	4	39				
				Totals		45	412	2282

M. J. Levy. Mr. Olcott includes with his own report a few observations by Mr. Stark of Tucson, Arizona, and Mr. Monnig sends in a very commendable list by Mr. V. Recinsky of Rowena, Texas.

Again we are indebted to Mr. Skaggs of Oakland, California, for copies of Julian Day Calendars for 1932. Members who have not already received their copies, are requested to inform the Recorder at once.

RY Sagittarii, *191033*, has reached 9th magnitude; the brightest since April, 1930. In the meantime this variable has been subject to marked fluctuations, especially on the rise to maximum. The minimum of S Apodis, *145971*, another of the R Coronae Borealis type variables, proved to be quite shallow, dropping

only a magnitude and a half below normal. R Coronae itself, although still at full brightness, magnitude 6.0, requires careful attention in order that any decrease in light may not be missed.

LEON CAMPBELL, Recorder.

January 13, 1932.

Fireball.—I wish to report quite a brilliant fireball which I saw over this village last night at 10:17 P.M., E.S.T.

My wife and I were out for a walk during the evening and while returning were remarking about the brilliancy of the stars in the region of Orion and Canis Major, farther to the west the stars were pretty well blotted out by the brilliancy of the moon which was at the quarter. While looking at Sirius, I caught an extra flash in the corner of my eye and turned to see the fireball coming almost exactly toward us. It was high and near the constellation of Triangulum when we first saw it and it came forward to a point near the star Algol where it burst and disappeared. The meteor was a brilliant red in color and probably one-fourth the size of the moon that then was shining. The duration of the fall which we saw was not over five seconds. The ball dimmed rapidly during that time and was about cherry red when it burst. There was a tail which lasted probably not more than the last two seconds. The appearance of the bursting ball was similar to that of a large rocket.

R. E. FRANKLIN.

128 Liberty Ave., Port Jefferson, New York, January 16, 1932.

Comet Notes

By G. VAN BIESBROECK

There are at present no known comets visible in ordinary instruments. Some expected periodic ones must also be quite faint. Amateur astronomers should not be discouraged by these circumstances. On the contrary, this ought to stimulate the search for new ones, because some of these wandering visitors have a way of turning up when least expected.

The most unusually mild winter at Williams Bay has caused so much cloudiness that there has been only one clear moonless night since last month. On that night (January 4) PERIODIC COMET SCHWASSMANN-WACHMANN could not be found on the plates centered on its position and showing stars down to the 16th magnitude. On that same night the faint trace of PERIODIC COMET NEUJMIN was recognized among the stars at the limit of visibility on the plate; it was not brighter than $17^{M}.5$ at that time and there is hardly any chance for further observations.

The weather has not permitted any re-observation of COMET NAGATI in the morning sky. Although its brightness is evidently much reduced, the gradual improvement of the conditions of visibility may make up for it, so that the search should be continued.

There is still a chance to recover three periodic comets which are located at present in the evening sky: SCHORR'S COMET which in 1918 was found to have a period of 7 years but was not seen in 1925; WOLF'S SECOND PERIODIC COMET, of which this is the first return; and PERIODIC COMET TEMPEL (3)-SWIFT. The first ones are probably both extremely faint but the third one should be in reach by

now; although the comet has been observed at three returns since it was first discovered in 1869 it has not been seen since 1908 because of its unfavorable position. At perihelion, when intrinsically brightest, it is almost behind the sun. It cannot be observed except several months before or after that point, when it is much less bright. To make things worse the period is so near six years that the same unfavorable circumstances repeat themselves for several successive returns.

In Circular 107 of the British Astronomical Association, A. C. D. Crommelin gives the orbit brought up to this time, from which he deduces the following search ephemeris:

1932	Perihelion April 1.0		Perihelion April 7.0	
	h m s	° ′	h m s	° ′
Jan. 26	22 19 6	−3 18	22 11 24	−3 58
Feb. 1	22 35 57	−1 53	22 27 48	−2 36
7	22 53 10	−0 25	22 44 44	−1 8
13	23 10 47	+1 8	23 2 5	+0 23

The positions are given for two assumptions differing by six days in the time of perihelion passage, which is the most uncertain element of the prediction. For our latitude the comet sets about 3 hours after the sun at the end of January but only two hours by the middle of February.

Williams Bay, Wisconsin, January 25, 1932.

Notes from Amateurs

Bonnevue Observatory

The pictures herewith relate to an amateur astronomer's accomplishment in building an observatory.

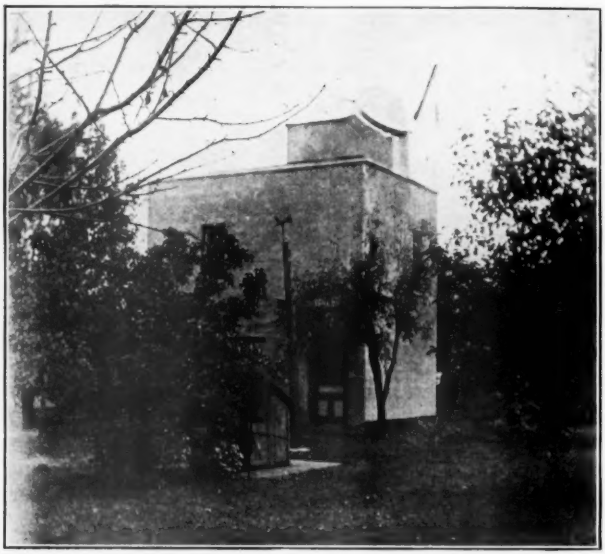
A small shop occupies the first floor of the building, while the second floor is given over to a small assembly room which will seat about twenty persons. This room will also become more or less "hobby headquarters." The main point of interest is the turret-house supported on "I" beams, which in turn rest on the masonry walls of the building. The roof remaining is flat, with parapet walls, making an ideal place from which to scan the heavens and for the use of portable telescope. The turret-house is approximately eight feet square affording standing room for several persons.

The telescope at present mounted carries a lens of five inches aperture, but this will later be replaced with a larger one. The turret is also arranged so that a second telescope can be mounted on the opposite side.

As will be apparent this type of mounting allows the telescope to sweep the entire heavens above the horizon, yet the observer may be comfortable within an enclosed and heated room in cold weather. Another strong appeal for this type of telescope is the comfortable position of the eyepiece, except in the extreme east, the telescope being mounted on the west side. Even when looking to the east the position of the eyepiece compares favorably with that of an average position for a pier-mounted refracting telescope.

The large rings are wood except the base of the revolving ring which is steel, a cross section of which would be approximately six inches by one-half inch. The base ring, which is securely framed into the building, is made of four layers of three-quarters of an inch material, with oak for the outside layers and white pine inside. The revolving ring forming the base of the turret has five layers again

using oak for the outside. This wood ring is securely bolted to the steel ring which is machined true. While the inside diameter of the wood rings is four and one-half feet, that of the steel ring is one and one-half inches less, thus protruding inside the wood ring three-quarters of an inch to form the track for the bearings. The bearings are grooved wheels about two inches in diameter, a roller thrust bearing at the bottom and ball bearing at the top. Six of these grooved wheels, four at the top and one at either side, carry the turret, and are adjustable for accurate setting for true north.

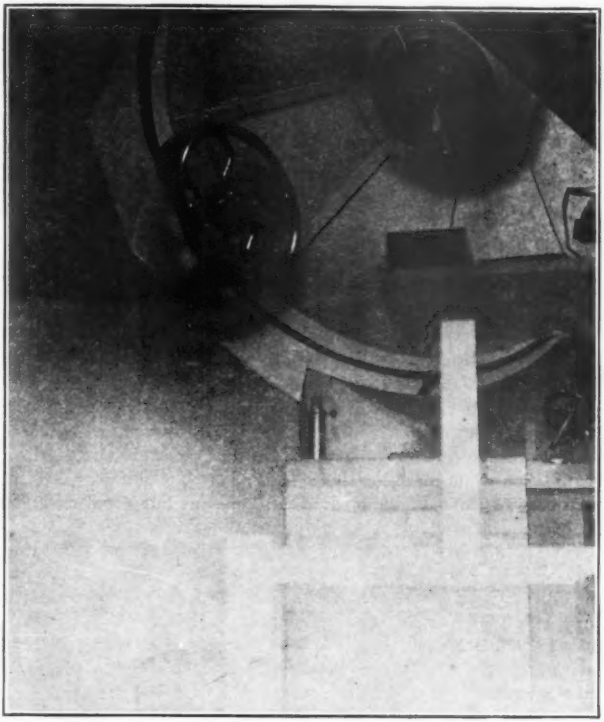


The driving mechanism consists of a gear of 1508, 24 pitch teeth on the outer circumference of the steel ring. A twenty-one tooth pinion meshes in this large gear. The shaft carrying the pinion revolves three times an hour when following a star. A synchronous motor of 1800 RPM, followed by a gear reducer 400 to 1, operates a worm with ninety teeth attached to the pinion shaft. The motor of course operates on standard time but the large gear compensates for the difference and turret will operate on sidereal time with slight error.

The bearing carrying the declination axis is very substantial. It was found that a four-inch condulet used in electric conduit work was quite ideal for the elbow of the telescope and to house the prism. Considerable deviation from usual practice in the matter of the right ascension circle has been made. As noted in the picture it is located in the center of the turret, revolving with it. A pendulum target, carrying lamp for illumination and magnifying lens is mounted on ball bearings, shows the position of turret with precision. This circle is sixteen inches in diameter and graduated to minutes, only half however being graduated. This right ascension circle is numbered east and west with "0" representing the meridian. With the use of the sidereal clock the number of hours and minutes east or west of the meridian the object may be located is determined and the turret set

accordingly.

For the general idea of the turret refracting telescope, the owner is indebted to Governor James Hartness of Springfield, Vermont, who has the first and as it seems until now the only telescope in the world of this type. It will be noted that in this form of telescope a finder is impossible or at least difficult to arrange, so that all objects are located by the use of circles. This may or may not be an objection depending on individual preference, but as many objects within reach of such a telescope are not visible to the eye, it is perhaps as well to use the circles for all.



It must be borne in mind that this is an amateur job, built locally. It is worthy of consideration by any amateur interested in a permanently mounted telescope, particularly in cold climates. The turret is also very practical for reflecting telescopes of moderate size.

J. Milo Webster.

Wyomissing (near Reading), Pennsylvania, October 26, 1931.

Direct and Retrograde Motions Illustrated.—As is well known, the apparent motions of the outer planets throughout the sky are characterized by periods of forward and backward directions which some pupils find difficult to understand.

In order to make these apparent motions thoroughly intelligible I used a device which I think may be useful to teachers.

I took a discarded alarm clock, removed the glass and reduced the length of its minute hand to about one-fifth of that of the hour hand. In this condition, when both hands moved normally, the tip of the minute hand made twelve revolutions while the hour hand made one. If the axle of the clock represents the sun, then the tips of the minute hand and the hour hand respectively represent the earth and Jupiter.

In order now to understand the apparent motion of Jupiter as seen from the earth, I fastened a rubber band to the tips of both hands. The rubber band represented the distance from the earth to Jupiter. Laying the clock flat on a table in the center of a room, we have, as it were, a part of a solar system at the center of the celestial sphere represented by the room. Let those objects in the room and on the walls situated more or less in the same plane as that of the face of the clock (ecliptic) represent the zodiacal constellations.

If we place the clock with the figure XII pointing south and the two hands pointing in that direction also we have the earth between the sun and Jupiter and therefore the latter is supposed to be crossing the meridian at midnight. The rubber band points directly southward.

Making the hands of the clock move counter-clockwise, the swifter motion of the earth causes the rubber bands to point more and more towards the west. If we translate this fact into Jupiter's apparent motion, we say that from that moment on, night after night, we shall see Jupiter moving toward the west among the zodiacal constellations.

When the minute hand has thus run the length of 14 minutes (which is the equivalent of about 50 days in the earth's motion) we see the rubber band reach the extreme western deviation at which moment Jupiter will be seen "stationary." From that moment on the rubber band begins to shift towards its initial direction. Jupiter is now moving eastward among the constellations. But from this time on, Jupiter will be more and more lost from view among the sun's rays. If we could see it when the two hands of the clock are in the same line (conjunction) Jupiter and the sun would be crossing the meridian at midday.

When the minute hand has made a total run of about 51 minutes, Jupiter, the sun, and the earth are forming again a right triangle. Jupiter is again stationary previous to its movings towards the west. The sun is more and more at the back of the earth and Jupiter is again seen at night.

We are nearing more and more the starting position of sun-earth-Jupiter, but before it is reached, the earth has to complete a whole circuit plus 1/12 of it. Jupiter has described 1/12 of its orbit toward the east, and we shall see it cross the meridian at midnight one month later than the year before.

ERNESTO NELSON.
Supervisor of Secondary Education, Argentine Republic.

R. Mejia, July 11, 1931.

Definition

This astronomical term has a double application; the first having relation to the telescope objective, the second, and more elusive, to the state of the atmosphere at the observing station. For the purpose of this article no notice will be taken of the first, as, being a function of the objective, it allows no great variation so that, for the amateur, it presents no great field for investigation.

The second, an atmospheric definition, can, however, be easily studied by the amateur with quite moderate instrumental equipment.

Theoretically, there is no limit to instrumental definition; that is to say, we can continue increasing the apertures and focal lengths of our telescopes, and, by the use of suitable eyepieces, secure magnifications of many thousands; but here the atmosphere intervenes completely nullifying the opticians' art. True it is that the astronomer can, by carefully choosing an elevated mountain peak in a good area, somewhat rectify matters. But mountain tops are not always available or accessible, and, even there, atmospheric troubles are met with.

The cause of these troubles is that we live at the bottom of an aerial ocean, which is, comparatively speaking, rather shallow, susceptible to changes in temperature, and therefore showing many degrees of density within a small area. Physiologically, we have every reason to be glad that air is such a poor conductor of heat, for on a hot summer's day asphalt, concrete, and iron surfaces absorb a great deal of heat, and hence may indicate temperatures ranging from about 100° to 200°. The air above them cannot absorb so much heat, but becomes warm by innumerable convection currents ascending through the whole, in exactly the same manner as the water in a kettle becomes warm through absorbing the heat from the bottom of the container, which is heated by a flame. The air, unlike the water in the kettle, is not confined, and, being free to move over a large area, it therefore takes a very long time to heat up. The changing densities due to this motion are therefore the cause of the varying definition.

When an object is in the zenith the effect is not as noticeable as when the altitude is slight; moreover, it is sometimes better on different sides of the zenith; for instance, an observer may be looking at an object over heated air arising from a city, and, on turning his telescope to another object over an extensive sheet of water, get an entirely different effect. It is a fact not generally known, that a sheet of moderately still water reflects a considerable amount of heat. When the conditions are right, on a hot summer afternoon, this phenomenon may be felt on the west side of Princes Bridge over the river Yarra at Melbourne; the writer has done so frequently. The effects here described are more or less local, and a few hours after sunset, they may become negligible. In a fixed observatory these conditions are frequently met with, so that a memo appended to an observer's work for the night frequently reads: "Definition poor at beginning but improving towards the end of the program." These conditions may be described as normal.

Suppose now the object to be a star; if the air is quite tranquil or homogeneous throughout, the observer sees in his field of view a disc of light surrounded by one or more rings of light, the disc appears to roll along without tremors of any kind, allowing micrometer setting to be made with ease; to such an observation the observer would append a weight of 10, the full weight; this has only happened a few times to the writer's knowledge; the more normal condition is for the star to present a certain amount of fuzziness, combined with an erratic movement across the field of view, calling for great care in making the micrometer setting, such an observation receiving a weight of 5 du to 7 du, the figures indicating the difficulty of setting, and the letters the appearance of the object, "d" meaning diffused and "u" unsteady.

Some years ago, the writer, for quite another purpose, was eager to find out the weights given to observations at observatories at various parts of the world and arrived at a mean result of 6.

At the Melbourne Observatory there is a certain type of definition which

compels the observer to weight his observations as low as 2 to 5 du, so that the images are slightly larger than normal, and have much the appearance of being viewed through running water. When such are the observing conditions the observer can safely say that the following day will be cloudy with rain probable; undoubtedly, therefore, such definition is associated with some approaching meteorological change. Somewhere about 1890 an American amateur astronomer, using the sun and moon for his purpose, was able to predict the direction of the wind for the following day, by carefully noting the progress of the ripples, which can be seen round these luminaries, and carefully charting them.

This phase of astronomy has been overlooked for a long time: no one seems to have bothered much to seek for the conditions that make atmospheric definition so variable. Here, then, is a chance for the amateur, with very moderate equipment, to render real service by correlating the following meteorological conditions with the preceding definition.

G. H. Woodhouse.

Melbourne, Australia.

Eyepieces—Low and High

The writer was much interested to note that the late Mr. Warner of the celebrated firm of Warner and Swazey, when on a visit to the Lick Observatory, especially asked that he might see the four objects, which, it so happened, he had never seen, namely: the *double* companion of γ Andromeda; the faint star *within* the annular nebula of Lyra; the dark sky between the stars in the great cluster in Hercules; and the *fifth* satellite of Jupiter. Dr. W. W. Campbell laughingly replied that *that* was some proposition; but he actually delivered the goods in full; and Mr. Warner saw all that he requested.

Now the amateur must be content to limit himself to the possibilities of his equipment,—small apertures, and limited powers; but there is an old rule of Edison's to the effect that, when one is trying out new stunts, he must be careful to try all of the tests except what he knows to be absolutely foolish; but before he gets through, he must be sure to try that too. And that is my sole excuse for this short bit of tyroism, with its almost incredible results.

First, as to the use of *very low* powers. The writer is one of those who must confess frankly to a great delight that he finds in the seeing of things beautiful in themselves, and simply for the beauty they reveal. And here I wish to emphasize what is usually neglected, namely, the startlingly dramatic effect of seeing all of such groups of stars as the Pleiades in one field. I have often watched this group in my old, 2-inch, binoculars (Lemaire, Paris, about 1885); and I have never seen any more beautiful astronomical object in any telescope; and I have seen the Saturnian system in the Lick 36-inch. This was the basis of my trying out very low powers on my little Mogey 3-inch. This glass is not a really first-class one, from the standpoint of the critical professional, as it gives only about fifty-fifty results on its concentric rings, as noted in "The Telescope" by the late Dr. Louis Bell; but my glass must be a fair one, judging from the results given herewith. While I have used low powers like 15 or 20 mostly on the Pleiades, yet there are hosts of others that are inviting, such as "The Beehive" in Cancer; Eta Telescopii, just east of the tail of Scorpio, and many others, with many fields in the Milky Way. I wish merely to call attention of all amateurs to this field of possible pleasure. What such use might do with larger telescopes can be only imagined.

High-Power and "Microscopic" Eyepieces. My attention was called to this

subject by a chance remark somewhere to the effect that a low-powered microscope might be used as the eyepiece of a telescope, but that the results were of doubtful value. But I also chanced to recall that, in the 90's, I had seen an article in *Nature*, showing how a cunning observer had used some such contraption, with a small telescope, and actually got fine results in watching such things as birds, insects, etc., from almost incredible distances; and though such instruments were shortly after that advertised in *Nature*, the subject seems to have been dropped; and I failed to find anything definite on it in my available literature. In my copy of Fath's *Astronomy*, 1926, on p. 45, I note that, after describing both positive and negative eyepieces, he says, "other and more complicated eyepieces have been devised, but as they are more expensive they are not in such general use"; and while some of those here referred to may be of the "microscopic" type, yet I am rather inclined to think that this whole matter has been neglected, from the standpoint of amateurs; for my results were obtained with very cheap eyepieces, and were most astonishing.

First, at hap-hazard, I put two plain lenses together in a short paper tube, with an old 1-inch lens (my boyhood microscope, and the eyepiece of my boyhood telescope), for the eyepiece; and for the objective, simply an old and discarded "bullseye" lens from an old 10-cent flashlight; these two lenses made my microscopic eyepiece. Of course, I had to stop down the bullseye lens with small diaphragms and the resultant power for it all, as a microscope, was about 24-fold magnification. When I tried this out on my 3-inch Mogey, I was surprised to find that it made a most excellent terrestrial eyepiece, with objects not inverted, and also with most clear definition. Many objects, from half a mile to five or ten miles distance behaved finely, both by day and also at night, so it encouraged me to try it out on the stars.

Microscopic Eyepiece on the Stars. The first thing that I tried was naturally that entrancing double-double, ϵ Lyrae. Now I have often seen one of the fine doubles with my best positive eyepiece, but not both, power 26; but with this new microscopic eyepiece, power about 400 plus or minus, I clearly got *both* the doubles. Then I tried it on Polaris. Now the companion of Polaris has always been a hard one with my eyes; even in 6-inch telescopes it does not look bright; but with my new eyepiece, I could clearly see the companion thrown out beyond the diffraction rings of the bright star. And with Antares, I actually saw the bright red center, and the bright green companion fairly well separated,—not with "Zeiss Definition" to be sure, nor without much chromatic distortion; but with the result of separation. Of course there are limits to this; and ϵ Bootes gave only a bright chromatic band, merely suggesting separation. So much for the stars; where my guess is that this eyepiece does its work by separating the images, distorted though they be, and highly chromatic, far enough from each other to get some separation; but it will not work so well on stars that are too bright.

The Moon with the Microscopic Eyepiece. I had mentioned this new work of mine to a friend, Mr. Fisher, Junior, of the Fisher Scientific Co., and he was so interested that he gave me a small pocket microscope, of German make just introduced on the market. This, marked for a power of 40, when put on my 3-inch Mogey, showed the moon with so many details that it seemed a new object to me; which justifies my anticipation that it will work wherever there is light enough but not too much, and much contrast and relief.

The Planets. So far I have obtained no good results with Jupiter or Mars; and I would not expect to. But I would ask all amateurs to try this, and give me

their results and their criticisms; and for the real professionals, I would most humbly and respectfully ask that they tell us amateurs if they are using the same thing under another name; for it is my distinct guess that this eyepiece might be used on occasions, even with the largest glasses or reflectors, as in the separation of close and faint doubles, or in the visual search for such fine things as the faint satellites of the planets, where wide separation might seem to be a prerequisite.

CHARLES SKEELE PALMER.

Pittsburgh, Pennsylvania, June 22, 1931.

Zodiacal Light Notes

By W. E. GLANVILLE

During the past month prevailing cloudiness has interfered with observations. On the following dates the morning Zodiacal Light was observed: December 15, 16, January 14, 15; the evening Zodiacal Light on December 29, 30, January 10, 13.

MORNING ZODIACAL LIGHT. On December 15 at 5:30 Alpha and Beta Librae were covered; Spica was on the south edge; Zeta Virginis was on the north boundary; the Light narrowed towards Regulus and could not be traced farther west, probably because of Jupiter.

On December 16 at 5:15 the range of the Light northward was extended to Alpha Serpentis. From Spica the Light was strong to Gamma and Eta Virginis, thence faint and narrow to Regulus. At 5:40 with the oncoming of dawn the faint section from Gamma Virginis west disappeared. From Spica to the horizon the brightness increased and the Light took on a broad-based beehive shape.

On January 14 at 5:00 A.M. the head of Scorpio including Antares was covered. The northern boundary passed slightly north of Zeta Ophiuchi. Alpha and Beta Librae were covered. At 5:40 Alpha and Beta Librae were clear of the Light; also the head of Scorpio was clear and the north boundary passed about 5° south of Gamma Ophiuchi. Thus during the time of observation the body of the Light had swung northward and except on the horizon was clear of the ecliptic.

On January 15 at 5:20 a similar shift of the body of the Light northward was observed.

EVENING ZODIACAL LIGHT. On December 29 at 6:15 P.M. the Light was seen as far east as Aries. The north boundary was indicated by Alpha and Beta Aquarii, the south by Delta Aquarii which was clear of the Light and Delta Capricorni on the edge. Color: grayish, smoky. Light was markedly north of the ecliptic so far as determined by the central axis. No evidence was seen of the so-called permanent band between the Pleiades and Hyades. Sky was entirely cloudless. At 7:45 the stubby eastern end of the band was pointed straight at the Aries asterism, thus suggesting a move northward as compared with the position at 6:15. On December 30 the luminosity was much greater than on the preceding evening, brighter than the galaxy area between Cassiopeia and Cygnus. On January 10 at 6:25 the Light was blurred and diffuse due perhaps to moonlight and Venus. At 8:30 Gamma and Alpha Pegasi were covered by the north boundary. It is interesting to note that an observer in the tropics on the same meridian and at the same time would have seen the Light as a band arching the

sky with the south boundary of the Square of Pegasus clear of the Light. On January 13 at 7:00 P.M. by screening off the five-day-old moon the north boundary was seen passing just south of Alpha Pegasi along 5° north of Alpha Aquarii, thence spreading northward to the horizon. No determination of the south boundary was possible on account of dense haze.

GEGENSCHEIN. On January 14 at 5:20 A.M. the Gegenschein, extremely faint, was seen southeast of Pollux; estimated diameters, 10° east and west, 8° north and south. The object, so to speak, stood alone; no band east or west could be detected.

Recently the writer had an opportunity to read the reports of Capt. F. J. Bayldon, R.N.R., who from 1889-1899 studied the Zodiacal Light during his voyages on board the *R.M.S. Aorangi* plying between Sydney, Australia, and Vancouver. He says that the Zodiacal Light is seen best at sea and that he found conditions better on the Pacific than on the Atlantic. During his decade of observations he found that in tropical latitudes the Zodiacal Light is visible as a band reaching across the entire sky throughout the night. A very important statement, the result of careful and frequent observations, is as follows:

"As the western cone sets and is followed by the band, the band assumes a cone shape (very faint in intensity)." He also noticed that the displacement of the central axis, northward or southward, is greatest at small elongation from the sun and decreases as elongation increases to opposition.

During February the Gegenschein may be observed passing through Cancer to west of the Sickle of Leo. The evening Zodiacal Light will be well placed for observation and reports will be welcome.

The Rectory, New Market, Maryland.

General Notes

Professor H. H. Plaskett, of the Harvard College Observatory, has recently been appointed to the Savilian professorship of astronomy at Oxford University, as successor to the late Professor Herbert Hall Turner. This professorship with a similar one in geometry was founded in 1619 and has been held since that time by such illustrious persons as Wren, Gregory, Bradley and others. Professor H. H. Plaskett is the son of Professor J. S. Plaskett, director of the Dominion Astrophysical Observatory at Victoria, British Columbia.

29 Canis Majoris, A Probable White Dwarf Star

There are two distinct theories of the origin of stellar energy at present holding the field. The first, and most widely held, is that the source of the energy of the stars is the annihilation of matter. This theory is associated particularly with the names of Eddington and Jeans. The second theory, associated particularly with the name of R. d'E. Atkinson of Rutgers University, is that transmutation of the various elements, and particularly the transmutation of hydrogen to helium is the source of stellar energy.

The writer will not go into detail concerning the relative merits and demerits of these two rival theories as the space does not permit. There is one thing apparent, however. That is this. If the annihilation theory holds good, a star will

radiate its mass away until nearly nothing is left. Therefore, all or nearly all white dwarfs, will be stars of low mass. On the other hand, by the Atkinson theory, as soon as the hydrogen supply of a star is exhausted, or nearly so, it will contract away from the main sequence, and end up as a white dwarf star, even though it have the mass of a super-giant. Therefore, if the source of energy is the transmutation of the elements, and not the annihilation of matter, one should, upon examining a list of spectroscopic binaries, find some pairs of stars of very high mass indeed, yet of rather low luminosity.

The writer found one very interesting star, apparently of this type, the O-star, 29 Canis Majoris. According to Russell, Dugan, and Stewart, while the mass function of the star is 4.58, the absolute visual magnitude is —0.8. The star is not an eclipsing variable, so 70 degrees is roughly the highest value that can be assigned the inclination of the orbit to the plane of the sky. Assume 70 degrees to be the actual inclination.

Only one spectrum is visible. Judging from the evidence of visual binaries, and of spectroscopic binaries with two sets of lines visible, the greatest mass that can be assigned the invisible star is one-half the mass of the brighter one. Therefore, under these assumptions the mass of the brighter star comes out 112 times that of the sun's; and the mass of the fainter one 56 times that of the sun.

These are somewhere near the lower limits of the masses, which may be much greater, but cannot well be very much smaller. The spectrum of 29 Canis Majoris is O7e, which corresponds roughly to a temperature of 19,000 C. Using this temperature, an absolute magnitude of —0.8, and a mass 112 times sun, we find, using the formula on page 732 of *Russell, Dugan, and Stewart's Astronomy*, that the diameter, volume, and density of the star with the visible spectrum are 1.84. 5.76, and 18.6 times that of the sun, respectively.

From the mass luminosity law we find that a star of mass 112 times sun, and surface temperature 19,000 C would have an absolute magnitude of —8.2.

This is 900 times as bright as 29 Canis Majoris actually is. Since for a given temperature the radius of a star varies as the square root of the luminosity and the volume as the cube of the radius, it is found that 29 Canis Majoris is 27,000 times as dense as a normal star of its mass and spectrum.

Such stars of high mass and low luminosity would not be easily detected save as spectroscopic binaries, for if the masses could not be measured directly, resort must be had to spectroscopic peculiarities which might be very hard to detect and interpret. Also, if the massive white dwarfs are as rare as the super-giant stars, there would be very few in the catalogues as they cannot be seen at great distances. Therefore it is not surprising that only one high mass white dwarf was found among the spectroscopic binaries, some three hundred in number, available for the writer's study.

Noah W. McLeod.

Christine, North Dakota.

Astronomy as a Panacea.—In the mind of the writer of an epitaph which is to be found in a cemetery at Muscatine, Iowa, astronomy is not only one of the exact sciences but also the *sine qua non* for the upbuilding of society and civilization. The epitaph reads as follows: "Let us get out of the ruts of the dark ages which have kept us in ignorance and bondage so long.

"Teach the young people astronomy that they may get the right conception of the universe and our Creator."

Summary of Sun-Spot Observations at Mount Holyoke College, 1931

Month	No. of Obs.	North of Equator No. of Groups	North of Equator Av. Lat.	South of Equator No. of Groups	South of Equator Av. Lat.	Av. No. at one Obs.	New Groups
January	19	3	+ 9°.1	1	—19°.3	0.94	4
February	16	10	10.1	3	6.5	2.81	13
March	15	7	6.9	4	10.8	2.13	10
April	18	12	9.3	3	4.7	2.78	14
May	16	8	9.2	2	14.9	1.69	9
June	5	1	5.6	0	....	1.00	1
September	5	3	11.0	0	....	1.40	3
October	18	2	13.5	2	14.2	0.94	3
November	12	5	12.2	3	1.7	1.42	8
December	9	4	+ 8.8	1	— 1.0	0.67	5
	133	55		19			70

Average number at one observation 1.68
Average latitude of groups north of equator +9°.4
Average latitude of groups south of equator —8°.6
No spots were found on 16 days of observation.
No record was kept from June 7 to September 22.
Most of the observations were made by Miss Helen Porter.

ANNE S. YOUNG.

John Payson Williston Observatory.

OBITUARY

C. J. Merfield, F. R. A. S.

(From a paper by John A. Moroney in *Bulletin No. 40 of the Astronomical Society of Victoria.*)

The tragic death on January 23, 1931, as the result of a motoring accident of C. J. Merfield, F.R.A.S., Chief Assistant Astronomer at the Melbourne Observatory and a well-known figure in the Astronomical Society of Victoria, came as a severe shock to everyone who knew him. It was on his way to Stawell that the fatal accident occurred. Mr. Merfield was a native of Stawell and had not revisited the place for many years. It is a curious irony of fate that he should die while on a journey to Stawell for the purpose of supervising the erection of a sun-dial which he had designed.

He was an Australian authority on eclipses and prepared the local data for most of the eclipses occurring in or near Australia. While an amateur he joined an expedition to Flint Island in 1901 and made the acquaintance of several American astronomers. He took part in the Melbourne Observatory eclipse expeditions to Bruni Island, Tasmania, in 1910; to Vavau in the Pacific in 1911 and to Glenthompson in Victoria on the occasion of the annular eclipse of 1916.

He was a Life Fellow of the Royal Astronomical Society of London, being elected in 1896; and a member of the Astronomy Committee of the Australian Nat. Research Council. He was also one time Mitglied der Astronomische Gesellschaft. When the Astronomical Society of Victoria was formed in 1922 Mr. Merfield was the first president and filled the position for several years.

His outstanding hobby was his ability as an amateur photographer and here he secured many prizes and awards. His work secured international recognition, being published in the well-known "Photograms of the Year."

Book Reviews

Astronomische Beobachtungsmethoden. Dr. J. Stobbe, 8 vo, 180 pp. (Urban & Schwarzenberg, Berlin, 1931. Price 11 marks.)

This book is a part of a vastly greater work, Handbuch der biologischen Arbeitsmethoden, which is being published by Prof. E. Abderholden of the University of Halle in collaboration with nearly a thousand scientific workers in the various fields. The portion under consideration deals only with astronomical methods of observation. It is divided into two main parts, the one dealing with astrometrical and the other with astrophysical methods. The subjects considered range from methods for developing a fundamental star catalog to observations of the sun by means of the Hale spectrohelioscope. The purpose of the book is not so much to give detailed and technical information as to describe the methods involved in such a manner that a reader with a reasonable general scientific training may follow the argument without difficulty. There are 49 cuts and 2 plates by way of illustrations. References to original sources of information are numerous. The book can be recommended to all who desire information in the field treated and who have a reading knowledge of the language. E.A.F.

Practical Astronomy, by Jason John Nassau. (McGraw-Hill Book Company, Inc. Price $3.00.)

This is the most recent book in the McGraw-Hill Astronomical Series. Its publication date is 1932 which shows that it is brand new. This volume consists of 221 pages and an index. It is divided into fourteen chapters which treat such subjects as time, latitude, azimuth, longitude, instruments.

It opens with an introductory chapter of eight pages which familiarizes the reader with the materials with which astronomy has to do. In the second chapter the several systems of coördinates are presented and explained as lines of reference. Four chapters are devoted to time, including the determination of it. At the close of the several chapters are found lists of problems for the purpose of putting into practice the principles presented.

The text is interspersed with numerous figures and photographs which aid the reader in comprehending the subject. The book is printed and bound in the usual style of the McGraw-Hill books and shows the usual careful and skilled workmanship. The book will be found well suited to courses arranged for the purpose of acquainting the student with the methods of routine work which is carried on at practically all of the large observatories.

The Universe in the Light of Modern Physics, by Max Plank. (W. W. Norton and Company, Inc., New York City. Price $2.00.)

The reading public has, in the last few years, become acquainted with the names of several persons who are leading in the modern scientific advances which are startling to some, astonishing to others, and mystifying to still others. One of these names is that of Dr. Max Planck, Professor of Theoretical Physics at the University of Berlin, and the author of the book before us. Because of the prominence of the author one may take up this volume with the assurance that he is to find in it statements which are authentic and well considered. Nor is he disappointed. Moreover, as is naturally the case, the one who has grasped most

thoroughly the significance of the ideas which he is treating is best able to expound them most clearly. The volume of 114 pages is devoted to an exposition of the major two new ideas of physical science, namely, relativity and the quantum theory. The former of these the author regards as not necessarily revolutionary, but the latter does involve new concepts and "unequivocally denies certain fundamental views which are essential to the whole structure of the classical theory."

The material is printed in clear, easily readable type, and the pages are not filled with mathematical symbols, so forbidding and so discouraging to the nonmathematically trained person. The ideas being new cannot, however, be fully understood without an effort on the part of the reader. But the book affords an excellent opportunity for those who are willing to put forth the effort to exercise their powers of analysis and comprehension. The translator, Mr. W. H. Johnston, has conferred a favor upon those, whose reading is limited to the English language, by bringing the writings of so prominent a scientist within their reach.

Publications of the Yerkes Observatory, Vol. VI. Micrometric Measures of Star Clusters, by Edward Emerson Barnard. (The University of Chicago Press. Price $4.00.)

The fact that from time to time since his death in 1923 important publications have appeared, based upon his observations, is an indication of the enormous amount of work accomplished by Professor Edward E. Barnard. The present volume is issued under the editorship of Edwin B. Frost, George Van Biesbroeck, and Mary R. Calvert. It consists of 106 octavo pages and contains an introduction and micrometric measures and rectangular coördinates of the stars in eighteen clusters. In an appendix are given the measures extending from 1897 to 1922, more than five hundred observations, made to determine the difference in declination of Atlas and Pleione. This exhaustive investigation shows the thoroughness of the data used in compiling this volume and characterizes it as entirely dependable and consequently extremely valuable.

Johann Kepler, 1571-1630, A Tercentenary Commemoration of his Life and Work. Prepared under the auspices of The History of Science Society. (The Williams and Wilkins Company, Baltimore, Md. Price $2.50.)

As the subtitle indicates, this volume is an account in permanent form of commemorative exercises held by The History of Science Society in joint session with Sections A, D, and L of the American Association for the Advancement of Science, at Cleveland, Ohio, on December 31, 1930. It contains as its main features the text of addresses presented on that occasion by Professor W. Carl Rufus, Kepler, as an Astronomer; by Professor D. J. Struik, Kepler as a Mathematician; Professor E. H. Johnson, Kepler and Mysticism; and also a Bibliography of Kepler's Works, prepared by F. E. Brasch, the secretary of the Society. The addresses afford very interesting reading matter concerning this picturesque character who possessed unusual genius and insight.

Sir Arthur Eddington, in a brief introduction, says of him: "I think it is not too fanciful to regard Kepler as in a particular degree the forerunner of the modern theoretical physicist. . . . It is only in the latest years that we have gone back to something like Kepler's outlook, so that the music of the spheres is no longer drowned by the roar of machinery."

The bibliography, which does not claim to be exhaustive, nevertheless contains more than eighty titles of original papers showing the versatility and produc-

tivity of this man. There are also nearly one hundred references to commentaries upon his works, showing how profoundly his work influenced the thought of his time and the succeeding period.

For those who are interested in tracing astronomical thought through the centuries, this volume will fill an important place.

Cosmic Distances, and **The Home of our Solar System in the Cosmos** are the titles of two pamphlets of approximately fifty pages each which have recently been received. They are written by Robert Hensling and issued by the publishing house called "The Iron Hammer," Leipzig. The price is 1.2 marks. These pamphlets contain descriptions of the more familiar objects in the sky, and are profusely illustrated. The author and publisher are to be congratulated upon the fine manner in which the best celestial photographs which have been made are here reproduced. The German people, and all who read German readily, will find in these pamphlets a source of much interesting information.

Publications Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge the receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

1. Publications of the Yerkes Observatory, Vol. VII, Part 1. Radial Velocities of 500 Stars of Spectral Class A, by Edwin B. Frost, Storrs B. Barrett, and Otto Struve. This may be purchased from the University of Chicago Press, price $1.50.
2. Photographische Sternkarten (Palisa-Wolf-Karten), Series XI (pages 201-210). These charts have been issued by and may be secured from Dr. J. Rheden, Türkenschanzstrasse 17, Vienna. Price 15 marks.
3. Publications of the University Observatory at Berlin-Babelsberg, as follows:
   Volume VIII, Part 5. The Bright Stars and the Rotation of the Galaxy, by K. F. Bottlinger.
   Volume VIII, Part 6. Investigations concerning Short-focus Photographic Objectives and their Use in Observing Variable Stars, by H. Schneller.
   Minor Publication, No. 10. Catalog and Ephemerides of Variable Stars for 1932, by R. Prager.
   Volume IX, Part 1. On the Theory of Variation of Meteor Radiants, by C. Hoffmeister.
   Volume IX, Part 2. Photographic-Photometric Study of the Bright Fixed Stars, by A. Brill.
4. Photographic Magnitudes of Stars Brighter than $14^{M}.0$ in Kapteyn's Selected Areas, Royal Observatory, Greenwich, under the direction of Sir Frank Dyson.